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-	138	polic\$3 near3 version\$1	USPAT; US-PGPUB	2003/10/21 11:32
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-	11	((polic\$3 near3 version\$1) and (new adj polic\$3)) and @ad<20000809	USPAT; US-PGPUB	2003/10/21 13:17
-	312	policy near5 id\$1	USPAT; US-PGPUB	2003/10/21 13:17
-	129	(policy near5 id\$1) and @ad<20000809	USPAT; US-PGPUB	2003/10/21 13:17
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US-PAT-NO: 6286052

DOCUMENT-IDENTIFIER: US 6286052 B1

TITLE: Method and apparatus for identifying network data
traffic flows and for applying quality of service
treatments to the flows

----- KWIC -----

Detailed Description Text - DETX (42):

Following the handle area 540 are a plurality of policy bindings 552, such as policy bindings 552a, 552b and 552c. The policy bindings 552 contain encoded versions of the information stored in the traffic flow data structure 234 that corresponds to the flow handle specified in field 550. Each policy binding 552, moreover, has two elements, a policy identifier element 554 and an encoded policy instance element 556. Basically, the policy identifier element 554 identifies the type or instance of policy element that is contained in the associated encoded policy instance element 556. Each policy identifier element 554 includes a plurality of fields, including a length field 558 (specifying its length), a **policy identifier (Policy ID) type field 560 and a policy identifier field 562**. Each encoded policy instance element 556 similarly includes a plurality of fields, including a length field 564 (specifying its length), an encapsulation type field 566 and an encoded policy element field 568.

Detailed Description Text - DETX (43):

The first policy binding 552a, for example, may contain an encoded copy of the source port identified by program 224 with the SetSourcePort() call 414a and stored at the respective traffic flow data structure 234. More specifically, message generator 230 loads policy identifier field 562a with the type or instance of the policy element (e.g., "source port"). In the preferred embodiment, this name is a Policy Identifier (PID) as specified in the Internet Engineering Task Force (IETF) draft document COPS Usage for Differentiated Services submitted by the Network Working Group, dated December 1998, and incorporated herein by reference in its entirety. A PID specifies a particular policy class (e.g., a type of policy data item) or policy instance (e.g., a particular instance of a given policy class) in a hierarchical arrangement. The **Policy ID type field 560a** contains a predefined value reflecting that field 562a contains information in PID format. Component 226 preferably includes a Policy Information Base (PIB) for use in deriving the particular policy identifiers, as described in COPS Usage for Differentiated Services.

Detailed Description Text - DETX (44):

The message generator 230 then accesses the source port information from the respective traffic flow data structure 234 and translates it into a machine independent format suitable for transmission across network 200. For example,

the source port information may be translated in accordance with the ASN.1 translation technique. The encapsulated version of the source port is then loaded in the encoded policy element field 568a of binding 552a. The encapsulation type field 566a contains a predefined value reflecting that the information in field 568a has been encapsulated according to ASN.1. Message generator 230 similarly builds additional bindings 552 that contain encapsulated versions of the source IP address, transport protocol, destination port number and destination IP address as specified by program 224 in API calls 414b-414e and stored at traffic flow data structure 234. Message generator 230 also formulates separate bindings 552 for each of the application-level data items established by the application program 224 through application-level API calls 416. Again, each of these application-level data items may be identified by a corresponding PID which is loaded in the Policy ID type field 562 of the respective binding 552. The application-level data item is then translated into a machine-independent format (e.g., through ASN.1) and loaded in the respective encoded policy element field 568, as described above.

US-PAT-NO: 6539026

DOCUMENT-IDENTIFIER: US 6539026 B1

TITLE: Apparatus and method for delay management in a data communications network

----- KWIC -----

Application Filing Date - AD (1):
19990315

Brief Summary Text - BSTX (24):

According to another aspect of the invention, updates to the network policy can be obtained by the policy controller and the storage locations in the delay controller can be reconfigured during operation of the data communications device to allow controlling a delay for data transmitted through the data communications device according to the updates in the network policy. In this manner, a data communications device using the invention offloads from the network policy server the burden of distributing any updates to the network policy. This allows each device to obtain the updates from a network policy server as needed, instead of requiring the network policy server to actively distribute new policies all at once. This distributes the load on the network policy server.

Detailed Description Text - DETX (17):

Through the use of distributed network policies, the data communications devices 200 of this invention can dynamically alter, update or reconfigure an existing delay management configuration to accommodate changes in the network policy. For instance, if the network policy in Table 1 is initially distributed, but then changes at a later time with the addition of more delay attributes and categories, the invention allows the data communication devices 200 to obtain the new policy and to dynamically reconfigure their internal delay management configuration.

Detailed Description Text - DETX (68):

Step 301 provides the ability to add or remove storage locations 259 from the series of storage locations 259-0 through 259-N each time the step is performed. As such, the invention allows the delay manager 201 to reconfigure itself if changes appear in the network policy 207. That is, the invention allows changes to be made at any time in the network policy 207, such as the addition or removal of delay categories and/or data attributes. In response, a delay manager configured with the invention can periodically re-execute steps 300 through 302, as illustrated by the periodic re-execution line 310. Alternatively, re-execution of steps 301 through 303 can be triggered by the arrival or manual loading of new network policy information 207 into the data

communications device 200. In this manner, the policy controller 250 in the delay manager(s) 201 in the data communications device(s) on network 100 periodically obtain the latest version of the network policy 207 from the network policy server 150 and can reconfigure the delay scheduler 251 and delay controller 252 via control commands 208 as previously described. This allows each data communications device 200 in an entire network to adapt to changes in a distributed network policy 207 with respect to the delay of data 205. Thus if new data types or data having new attributes becomes present on a network, the data communications devices 200 that use this invention can adapt to the new delay requirements without manually updating hardware or software within the devices 200.

Network Working Group
Request for Comments: 3317
Category: Informational

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March 2003

Differentiated Services Quality of Service Policy Information Base

Status of this Memo

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Abstract

This document describes a Policy Information Base (PIB) for a device implementing the Differentiated Services Architecture. The provisioning classes defined here provide policy control over resources implementing the Differentiated Services Architecture. These provisioning classes can be used with other none Differentiated Services provisioning classes (defined in other PIBs) to provide for a comprehensive policy controlled mapping of service requirement to device resource capability and usage.

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Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

Glossary

PRC Provisioning Class. A type of policy data. See [POLTERM].
PRI Provisioning Instance. An instance of a PRC. See [POLTERM].

PIB Policy Information Base. The database of policy information.
See [POLTERM].
PDP Policy Decision Point. See [RAP-FRAMEWORK].
PEP Policy Enforcement Point. See [RAP-FRAMEWORK].
PRID Provisioning Instance Identifier. Uniquely identifies an
instance of a PRC.

Introduction

[SPPI] describes a structure for specifying policy information that can then be transmitted to a network device for the purpose of configuring policy at that device. The model underlying this structure is one of well-defined provisioning classes and instances of these classes residing in a virtual information store called the Policy Information Base (PIB).

This document specifies a set of provisioning classes specifically for configuring QoS Policy for Differentiated Services [DSARCH].

One way to provision policy is by means of the COPS protocol [COPS], with the extensions for provisioning [COPS-PR]. This protocol supports multiple clients, each of which may provision policy for a specific policy domain such as QoS. The PRCs defined in this DiffServ QoS PIB are intended for use by the COPS-PR diffServ client type. Furthermore, these PRCs are in addition to any other PIBs that may be defined for the diffServ client type in the future, as well as the PRCs defined in the Framework PIB [FR-PIB].

Relationship to the DiffServ Informal Management Model

This PIB is designed according to the Differentiated Services Informal Management Model documented in [MODEL]. The model describes the way that ingress and egress interfaces of a 'n'-port router are modeled. It describes the configuration and management of a DiffServ interface in terms of a Traffic Conditioning Block (TCB) which contains, by definition, zero or more classifiers, meters, actions, algorithmic droppers, queues and schedulers. These elements are

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arranged according to the QoS policy being expressed, and are always in that order. Traffic may be classified; classified traffic may be metered; each stream of traffic identified by a combination of classifiers and meters may have some set of actions performed on it; it may have dropping algorithms applied and it may ultimately be stored into a queue before being scheduled out to its next destination, either onto a link or to another TCB. When the treatment for a given packet must have any of those elements repeated in a way that breaks the permitted sequence (classifier, meter, action, algorithmic dropper, queue, scheduler), this must be modeled by cascading multiple TCBs.

The PIB represents this cascade by following the "Next" attributes of the various elements. They indicate what the next step in DiffServ processing will be, whether it be a classifier, meter, action, algorithmic dropper, queue, scheduler or a decision to now forward a packet.

The PIB models the individual elements that make up the TCBs. The higher level concept of a TCB is not required in the parameterization or in the linking together of the individual elements, hence it is not used in the PIB itself and is only mentioned in the text for relating the PIB with the [MODEL]. The actual distinguishing of which TCB a specific element is a part of is not needed for the instrumentation of a device to support the functionalities of DiffServ, but it is useful for conceptual reasons. By not using the TCB concept, this PIB allows any grouping of elements to construct TCBs, using rules indicated by the [MODEL]. This will minimize changes to this PIB if rules in [MODEL] change.

The notion of a Data Path is used in this PIB to indicate the DiffServ processing a packet may experience. This Data Path is distinguished based on the Role Combination, Capability Set, and the Direction of the flow the packet is part of. A Data Path Table Entry indicates the first of possibly multiple elements that will apply DiffServ treatment to the packet.

1. PIB Overview

This PIB is structured based on the need to configure the sequential DiffServ treatments being applied to a packet, and the parameterization of these treatments. These two aspects of the configuration are kept separate throughout the design of the PIB, and are fulfilled using separate tables and data definitions.

In addition, the PIB includes tables describing the capabilities and limitations of the device using a general extensible framework.

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These tables are reported to the PDP and assist the PDP with the configuration of functional elements that can be realized by the device.

This capabilities and limitations exchange allows a single or multiple devices to support many different variations of a functional datapath element. Allowing diverse methods of providing a general functional datapath element.

In this PIB, the ingress and egress portions of a router are configured independently but in the same manner. The difference is distinguished by an attribute in a table describing the start of the data path. Each interface performs some or all of the following high-level functions:

- Classify each packet according to some set of rules.
- Determine whether the data stream the packet is part of is within or outside its metering parameters.
- Perform a set of resulting actions such as counting and marking of the traffic with a Differentiated Services Code Point (DSCP) as defined in [DSFIELD].
- Apply the appropriate drop policy, either simple or complex

algorithmic drop functionality.

- Enqueue the traffic for output in the appropriate queue, whose scheduler may shape the traffic or simply forward it with some minimum rate or maximum latency.

The PIB therefore contains the following elements:

Data Path Table

This describes the starting point of DiffServ data paths within a single DiffServ device. This class describes interface role combination and interface direction specific data paths.

Classifier Tables

A general extensible framework for specifying a group of filters.

Meter Tables

A general extensible framework and one example of a parameterization table - TBParam table, applicable for Simple Token Bucket Meter, Average Rate Meter, Single Rate Three Color Meter, Two Rate Three Color Meter, and Sliding Window Three Color Meter.

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Action Tables

A general extensible framework and example of parameterization tables for Mark action. The "multiplexer" and "null" actions described in [MODEL] are accomplished implicitly by means of the Prid structures of the other elements.

Algorithmic Dropper Tables

A general extensible framework for describing the dropper functional datapath element. This includes the absolute dropper and other queue measurement dependent algorithmic droppers.

Queue and Scheduler Tables

A general extensible framework for parameterizing queuing and scheduler systems. Notice Shaper is considered as a type of scheduler and is included here.

Capabilities Tables

A general extensible framework for defining the capabilities and limitations of the elements listed above. The capability tables allow intelligent configuration of the elements by a PDP.

Structure of the PIB

1. General Conventions

The PIB consists of PRCs that represent functional elements in the data path (e.g., classifiers, meters, actions), and classes that specify parameters that apply to a certain type of functional element (e.g., a Token Bucket meter or a Mark action). Parameters are typically specified in a separate PRC to enable the use of parameter classes by multiple policies.

Functional element PRCs use the Prid TC (defined in [SPPI]) to indicate indirection. A Prid is an object identifier that is used to specify an instance of a PRC in another table. A Prid is used to point to parameter PRC that applies to a functional element, such as which filter should be used for a classifier element. A Prid is also used to specify an instance of a functional element PRC that describes what treatment should be applied next for a packet in the data path.

Note that the use of Prids to specify parameter PRCs allows the same functional element PRC to be extended with a number of different types of parameter PRC's. In addition, using Prids to indicate the next functional datapath element allows the elements to be ordered in any way.

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2. DiffServ Data Paths

This part of the PIB provides instrumentation for connecting the DiffServ Functional Elements within a single DiffServ device. Please refer to [MODEL] for discussions on the valid sequencing and grouping of DiffServ Functional Elements. Given some basic information, e.g., the interface capability, role combination and direction, the first DiffServ Functional Element is determined. Subsequent DiffServ Functional Elements are provided by the "Next" pointer attribute of each entry of data path tables. A description of how this "Next" pointer is used in each table is provided in their respective DESCRIPTION clauses.

2.1. Data Path PRC

The Data Path PRC provides the DiffServ treatment starting points for all packets of this DiffServ device. Each instance of this PRC specifies the interface capability, role combination and direction for the packet flow. There should be at most two entries for each instance (interface type, role combination, interface capability), one for ingress and one for egress. Each instance provides the first DiffServ Functional Element that each packet, at a specific interface (identified by the roles assigned to the interface) traveling in a specific relative direction, should experience. Notice this class is interface specific, with the use of interface type capability set and RoleCombination. To indicate explicitly that there are no DiffServ treatments for a particular interface type capability set, role combination and direction, an instance of the Data Path PRC can be created with zeroDotZero in the dsDataPathStart attribute. This situation can also be indicated implicitly by not supplying an instance of a Data Path PRC for that particular interface type capability set, role combination and direction. The explicit/implicit selection is up to the implementation. This means that the PEP should perform normal IP device processing when zeroDotZero is used in the dsDataPathStart attribute, or when the entry does not exist. Normal IP device processing will depend on the device; for example, this can be forwarding the packet.

Based on implementation experience of network devices where data path

functional elements are implemented in separate physical processors or application specific integrated circuits, separated by switch fabric, it seems that more complex notions of data path are required within the network device to correlate the different physically separate data path functional elements. For example, ingress processing may have determined a specific ingress flow that gets aggregated with other ingress flows at an egress data path functional element. Some of the information determined at the ingress data path functional element may need to be used by the egress data path

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functional element. In numerous implementations, such information has been carried by adding it to the frame/memory block used to carry the flow within the network device; some implementers have called such information a "preamble" or a "frame descriptor". Different implementations use different formats for such information. Initially, one may think such information has implementation details within the network device that does not need to be exposed outside of the network device. But from Policy Control point of view, such information will be very useful in determining network resource usage feedback from the network device to the policy server. This is accomplished by using the Internal Label Marker and Filter PRCs defined in [FR-PIB].

3. Classifiers

The classifier and classifier element tables determine how traffic is sorted out. They identify separable classes of traffic, by reference to appropriate filters, which may select anything from an individual micro-flow to aggregates identified by DSCP.

The classification is used to send these separate streams to appropriate Meter, Action, Algorithmic Dropper, Queue and Scheduler elements. For example, to indicate a multi-stage meter, sub-classes of traffic may be sent to different meter stages: e.g., in an implementation of the Assured Forwarding (AF) PHB [AF-PHB], AF11 traffic might be sent to the first meter, AF12 traffic might be sent to the second and AF13 traffic sent to the second meter stage's out-of-profile action.

The concept of a classifier is the same as described in [MODEL]. The structure of the classifier and classifier element tables, is the same as the classifier described in [MODEL]. Classifier elements have an associated precedence order solely for the purpose of resolving ambiguity between overlapping filters. A filter with higher values of precedence are compared first; the order of tests for entries of the same precedence is unimportant.

A datapath may consist of more than one classifier. There may be an overlap of filter specification between filters of different classifiers. The first classifier functional datapath element encountered, as determined by the sequencing of diffserv functional datapath elements, will be used first.

An important form of classifier is "everything else": the final stage of the classifier i.e., the one with the lowest precedence, must be "complete" since the result of an incomplete classifier is not

When a classifier PRC is instantiated at the PEP, it should always have at least one classifier element table entry, the "everything else" classifier element, with its filter matching all IP packets. This "everything else" classifier element should be created by the PDP as part of the classifier setup. The PDP has full control of all classifier PRIs instantiated at the PEP.

The definition of the actual filter to be used by the classifier is referenced via a Prid: this enables the use of any sort of filter table that one might wish to design, standard or proprietary. No filters are defined in this PIB. However, standard filters for IP packets are defined in the Framework PIB [FR-PIB].

3.1. Classifier PRC

Classifiers, used in various ingress and egress interfaces, are organized by the instances of the Classifier PRC. A data path entry points to a classifier entry. A classifier entry identifies a list of classifier elements. A classifier element effectively includes the filter entry, and points to a "next" classifier entry or some other data path functional element.

3.2. Classifier Element PRC

Classifier elements point to the filters which identify various classes of traffic. The separation between the "classifier element" and the "filter" allows us to use many different kinds of filters with the same essential semantics of "an identified set of traffic". The traffic matching the filter corresponding to a classifier element is given to the "next" data path functional element identified in the classifier element.

An example of a filter that may be pointed to by a Classifier Element PRI is the frwkIpFilter PRC, defined in [FR-PIB].

4. Meters

A meter, according to [MODEL] section 5, measures the rate at which packets composing a stream of traffic pass it, compares this rate to some set of thresholds, and produces some number (two or more) of potential results. A given packet is said to "conform" to the meter if, at the time the packet is being looked at, the stream appears to be within the meter's profile. PIB syntax makes it easiest to define this as a sequence of one or more cascaded pass/fail tests, modeled here as if-then-else constructs. It is important to understand that this way of modeling does not imply anything about the implementation being "sequential": multi-rate/multi-profile meters, e.g., those designed to support [SRTCM], [TRTCM], or [TSWTCM] can still be

modeled this way even if they, of necessity, share information between the stages: the stages are introduced merely as a notational convenience in order to simplify the PIB structure.

4.1. Meter PRC

The generic meter PRC is used as a base for all more specific forms of meter. The definition of parameters specific to the type of meter used is referenced via a pointer to an instance of a PRC containing those specifics. This enables the use of any sort of specific meter table that one might wish to design, standard or proprietary. One specific meter table is defined in this PIB module. Other meter tables may be defined in other PIB modules.

4.2. Token-Bucket Parameter PRC

This is included as an example of a common type of meter. Entries in this class are referenced from the dsMeterSpecific attributes of meter PRC instances. The parameters are represented by a rate dsTBParamRate, a burst size dsTBParamBurstSize, and an interval dsTBParamInterval. The type of meter being parameterized is indicated by the dsTBParamType attribute. This is used to determine how the rate, burst, and rate interval parameters are used. Additional meter parameterization classes can be defined in other PIBs when necessary.

5. Actions

Actions include "no action", "mark the traffic with a DSCP" or "specific action". Other tasks such as "shape the traffic" or "drop based on some algorithm" are handled in other functional datapath elements rather than in actions. The "multiplexer", "replicator", and "null" actions described in [MODEL] are accomplished implicitly through various combinations of the other elements.

This PIB uses the Action PRC dsActionTable to organize one Action's relationship with the element(s) before and after it. It allows Actions to be cascaded to enable that multiple Actions be applied to a single traffic stream by using each entry's dsActionNext attribute. The dsActionNext attribute of the last action entry in the chain points to the next element in the TCB, if any, e.g., a Queueing element. It may also point at a next TCB.

The parameters needed for the Action element will depend on the type of Action to be taken. Hence the PIB allows for specific Action Tables for the different Action types. This flexibility allows additional Actions to be specified in other PIBs and also allows for the use of proprietary Actions without impact on those defined here.

One may consider packet dropping as an Action element. Packet dropping is handled by the Algorithmic Dropper datapath functional element.

5.1. DSCP Mark Action PRC

This Action is applied to traffic in order to mark it with a DiffServ Codepoint (DSCP) value, specified in the dsDscpMarkActTable.

6. Queueing Elements

These include Algorithmic Droppers, Queues and Schedulers, which are all inter-related in their use of queueing techniques.

6.1. Algorithmic Dropper PRC

Algorithmic Droppers are represented in this PIB by instances of the Algorithmic Dropper PRC. An Algorithmic Dropper is assumed to operate indiscriminately on all packets that are presented at its input; all traffic separation should be done by classifiers and meters preceding it.

Algorithmic Dropper includes many types of droppers, from the simple always dropper to the more complex random dropper. This is indicated by the dsAlgDropType attribute.

Algorithmic Droppers have a close relationship with queuing; each Algorithmic Dropper Table entry contains a dsAlgDropQMeasure attribute, indicating which queue's state affects the calculation of the Algorithmic Dropper. Each entry also contains a dsAlgDropNext attribute that indicates to which queue the Algorithmic Dropper sinks its traffic.

Algorithmic Droppers may also contain a pointer to a specific detail of the drop algorithm, dsAlgDropSpecific. This PIB defines the detail for three drop algorithms: Tail Drop, Head Drop, and Random Drop; other algorithms are outside the scope of this PIB module, but the general framework is intended to allow for their inclusion via other PIB modules.

One generally-applicable parameter of a dropper is the specification of a queue-depth threshold at which some drop action is to start. This is represented in this PIB, as a base attribute, dsAlgDropQThreshold, of the Algorithmic Dropper entry. The attribute, dsAlgDropQMeasure, specifies which queue's depth dsAlgDropQThreshold is to be compared against.

- o An Always Dropper drops every packet presented to it. This type of dropper does not require any other parameter.
- o A Tail Dropper requires the specification of a maximum queue depth threshold: when the queue pointed at by dsAlgDropQMeasure reaches that depth threshold, dsAlgDropQThreshold, any new traffic arriving at the dropper is discarded. This algorithm uses only parameters that are part of the dsAlgDropEntry.
- o A Head Dropper requires the specification of a maximum queue depth threshold: when the queue pointed at by dsAlgDropQMeasure reaches

that depth threshold, dsAlgDropQThreshold, traffic currently at the head of the queue is discarded. This algorithm uses only parameters that are part of the dsAlgDropEntry.

- o Random Droppers are recommended as a way to control congestion, in [QUEUEMGMT] and called for in the [AF-PHB]. Various implementations exist, that agree on marking or dropping just enough traffic to communicate with TCP-like protocols about congestion avoidance, but differ markedly on their specific parameters. This PIB attempts to offer a minimal set of controls for any random dropper, but expects that vendors will augment the PRC with additional controls and status in accordance with their implementation. This algorithm requires additional parameters on top of those in dsAlgDropEntry; these are discussed below.

A Dropper Type of other is provided for the implementation of dropper types not defined here. When the Dropper Type is other, its full specification will need to be provided by another PRC referenced by dsAlgDropSpecific. A Dropper Type of Multiple Queue Random Dropper is also provided; please reference section 5.5.3 of this document for more details.

6.2. Random Dropper PRC

One example of a random dropper is a RED-like dropper. An example of the representation chosen in this PIB for this element is shown in Figure 1.

Random droppers often have their drop probability function described as a plot of drop probability (P) against averaged queue length (Q). (Qmin, Pmin) then defines the start of the characteristic plot. Normally Pmin=0, meaning that with average queue length below Qmin, there will be no drops. (Qmax, Pmax) defines a "knee" on the plot, after which point the drop probability become more progressive (greater slope). (Qclip, 1) defines the queue length at which all

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packets will be dropped. Notice this is different from Tail Drop because this uses an averaged queue length. Although it is possible for Qclip = Qmax.

In the PIB module, dsRandomDropMinThreshBytes and dsRandomDropMinThreshPkts represent Qmin. dsRandomDropMaxThreshBytes and dsRandomDropMaxThreshPkts represent Qmax. dsAlgDropQThreshold represents Qclip. dsRandomDropProbMax represents Pmax. This PIB does not represent Pmin (assumed to be zero unless otherwise represented).

In addition, since message memory is finite, queues generally have some upper bound above which they are incapable of storing additional traffic. Normally this number is equal to Qclip, specified by dsAlgDropQThreshold.

Each random dropper specification is associated with a queue. This allows multiple drop processes (of same or different types) to be

associated with the same queue, as different PHB implementations may require. This also allows for sequences of multiple droppers if necessary.

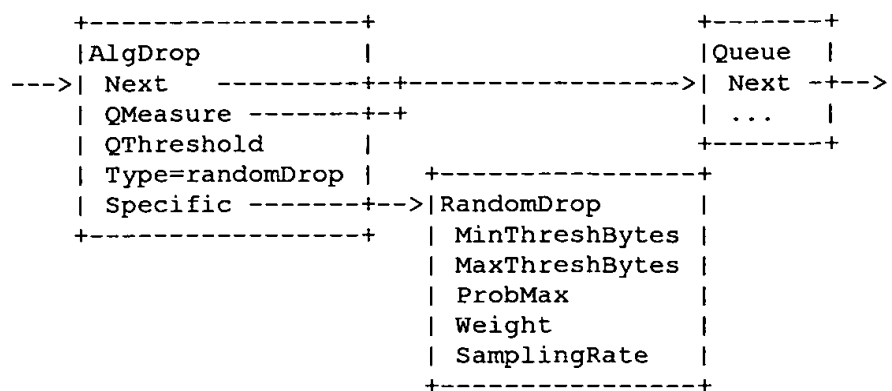


Figure 1: Example Use of the RandomDropTable for Random Droppers

The calculation of a smoothed queue length may also have an important bearing on the behavior of the dropper: parameters may include the sampling interval or rate, and the weight of each sample. The performance may be very sensitive to the values of these parameters and a wide range of possible values may be required due to a wide range of link speeds. Most algorithms include a sample weight, represented here by dsRandomDropWeight. The availability of dsRandomDropSamplingRate as readable is important; the information provided by the Sampling Rate is essential to the configuration of dsRandomDropWeight. Having the Sampling Rate be configurable is also

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helpful, because as line speed increases, the ability to have queue sampling be less frequent than packet arrival is needed. Note however that there is ongoing research on this topic, see e.g., [ACTQMGMT] and [AQMROUNTER].

Additional parameters may be added in an enterprise PIB module, e.g., by using AUGMENTS on this class, to handle aspects of random drop algorithms that are not standardized here.

NOTE: Deterministic Droppers can be viewed as a special case of Random Droppers with the drop probability restricted to 0 and 1. Hence Deterministic Droppers might be described by a Random Dropper with Pmin = 0, Pmax = 1, Qmin = Qmax = Qclip, the averaged queue length at which dropping occurs.

6.3. Queues and Schedulers

The Queue PRC models simple FIFO queues, as described in [MODEL] section 7.1.1. The Scheduler PRC allows flexibility in constructing both simple and somewhat more complex queueing hierarchies from those queues. Of course, since TCBs can be cascaded multiple times on an interface, even more complex hierarchies can be constructed that way also.

Queue PRC instances are pointed at by the "next" attributes of the

upstream elements e.g., dsMeterSucceedNext. Note that multiple upstream elements may direct their traffic to the same Queue PRI. For example, the Assured Forwarding PHB suggests that all traffic marked AF11, AF12, or AF13 be placed in the same queue after metering, without reordering. This would be represented by having the dsMeterSucceedNext of each upstream meter point at the same Queue PRI.

NOTE: Queue and Scheduler PRIs are for data path description; they both use Scheduler Parameterization Table entries for diffserv treatment parameterization.

A Queue Table entry specifies the scheduler it wants service from by use of its Next pointer.

Each Scheduler Table entry represents the algorithm in use for servicing the one or more queues that feed it. [MODEL] section 7.1.2 describes a scheduler with multiple inputs: this is represented in the PIB by having the scheduling parameters be associated with each input. In this way, sets of Queues can be grouped together as inputs to the same Scheduler. This class serves to represent the example scheduler described in the [MODEL]: other more complex representations might be created outside of this PIB.

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Both the Queue PRC and the Scheduler PRC use instances of the Scheduler Parameterization PRC to specify diffserv treatment parameterization. Scheduler Parameter PRC instances are used to parameterize each input that feeds into a scheduler. The inputs can be a mixture of Queue PRI's and Scheduler PRI's. Scheduler Parameter PRI's can be used/reused by one or more Queue and/or Scheduler Table entries.

For representing a Strict Priority scheduler, each scheduler input is assigned a priority with respect to all the other inputs feeding the same scheduler, with default values for the other parameters. A higher-priority input which contains traffic that is not being delayed for shaping will be serviced before a lower-priority input.

For Weighted Scheduling methods e.g., WFQ, WRR, the "weight" of a given scheduler input is represented with a Minimum Service Rate leaky-bucket profile that provides a guaranteed minimum bandwidth to that input, if required. This is represented by a rate dsMinRateAbsolute; the classical weight is the ratio between that rate and the interface speed, or perhaps the ratio between that rate and the sum of the configured rates for classes. Alternatively, the rate may be represented by a relative value, as a fraction of the interface's current line rate, dsMinRateRelative to assist in cases where line rates are variable or where a higher-level policy might be expressed in terms of fractions of network resources. The two rate parameters are inter-related and changes in one may be reflected in the other.

For weighted scheduling methods, one can say loosely, that WRR focuses on meeting bandwidth sharing, without concern for relative delay amongst the queues, where WFQ control both queue service order and amount of traffic serviced, providing meeting bandwidth sharing

and relative delay ordering amongst the queues.

A queue or scheduled set of queues (which is an input to a scheduler) may also be capable of acting as a non-work-conserving [MODEL] traffic shaper: this is done by defining a Maximum Service Rate leaky-bucket profile in order to limit the scheduler bandwidth available to that input. This is represented by a rate `dsMaxRateAbsolute`; the classical weight is the ratio between that rate and the interface speed, or perhaps the ratio between that rate and the sum of the configured rates for classes. Alternatively, the rate may be represented by a relative value, as a fraction of the interface's current line rate, `dsMaxRateRelative`. There was discussion in the working group about alternative modeling approaches, such as defining a shaping action or a shaping element. We did not take this approach because shaping is in fact something a scheduler does to its inputs, (which we model as a queue with a

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maximum rate or a scheduler whose output has a maximum rate) and we felt it was simpler and more elegant to simply describe it in that context. Additionally, multi-rate shaper [SHAPER] can be represented by the use of multiple `dsMaxRateTable` entries.

Other types of priority and weighted scheduling methods can be defined using existing parameters in `dsMinRateEntry`. NOTE: `dsSchedulerMethod` uses `AutonomousType` syntax, with the different types of scheduling methods defined as `OBJECT-IDENTITY`. Future scheduling methods may be defined in other PIBs. This requires an `OBJECT-IDENTITY` definition, a description of how the existing objects are reused, if they are, and any new objects they require.

NOTE: Hierarchical schedulers can be parameterized using this PIB by having Scheduler Table entries feeds into Scheduler Table entry.

7. Specifying Device Capabilities

The DiffServ PIB uses the Base PRC classes `frwkPrcSupportTable` and `frwkCompLimitsTable` defined in [FR-PIB] to specify what PRC's are supported by a PEP and to specify any limitations on that support. The PIB also uses the capability PRC's `frwkCapabilitySetTable` and `frwkIfRoleComboTable` defined in [FR-PIB] to specify the device's capability sets, interface types, and role combinations. Each instance of the capability PRC `frwkCapabilitySetTable` contains an OID that points to an instance of a PRC that describes some capability of that interface type. The DiffServ PIB defines several of these capability PRCs, that assist the PDP with the configuration of DiffServ functional elements that can be implemented by the device. Each of these capability PRCs contains a direction attribute that specifies the direction for which the capability applies. This attribute is defined in a base capability PRC, which is extended by each specific capability PRC.

Classification capabilities, which specify the information elements the device can use to classify traffic, are reported using the `dsIfClassificationCaps` PRC. Metering capabilities, which indicate what the device can do with out-of-profile packets, are specified using the `dsIfMeteringCaps` PRC. Scheduling capabilities, such as the

number of inputs supported, are reported using the dsIfSchedulingCaps PRC. Algorithmic drop capabilities, such as the types of algorithms supported, are reported using the dsIfAlgDropCaps PRC. Queue capabilities, such as the maximum number of queues, are reported using the dsIfQueueCaps PRC. Maximum Rate capabilities, such as the maximum number of max rate Levels, are reported using the dsIfMaxRateCaps PRC.

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Two PRC's are defined to allow specification of the element linkage capabilities of the PEP. The dsIfElmDepthCaps PRC indicates the maximum number of functional datapath elements that can be linked consecutively in a datapath. The dsIfElmLinkCaps PRC indicates what functional datapath elements may follow a specific type of element in a datapath.

The capability reporting classes in the DiffServ and Framework PIB are meant to allow the PEP to indicate some general guidelines about what the device can do. They are intended to be an aid to the PDP when it constructs policy for the PEP. These classes do not necessarily allow the PEP to indicate every possible configuration that it can or cannot support. If a PEP receives a policy that it cannot implement, it must notify the PDP with a failure report. Currently [COPS-PR] error handling mechanism as specified in [COPS-PR] sections 4.4, 4.5, and 4.6 completely handles all known error cases of this PIB; hence no additional methods or PRCs need to be specified here.

PIB Usage Example

This section provides some examples on how the different table entries of this PIB may be used together for a DiffServ Device. The usage of each individual attribute is defined within the PIB module itself. For the figures, all the PIB table entry and attribute names are assumed to have "ds" as their first common initial part of the name, with the table entry name assumed to be their second common initial part of the name. "0.0" is being used to mean zeroDotZero. And for Scheduler Method "= X" means "using the OID of diffServSchedulerX".

1. Data Path Example

Notice Each entry of the DataPath table is used for a specific interface type handling a flow in a specific direction for a specific functional role-combination. For our example, we just define one such entry.

```
+-----+
|DataPath      |
| CapSetName ="IfCap1"|
| Roles = "A+B"  |
| IfDirection=Ingress |
| Start -----+---->|Clfr      |
+-----+          | Id=Dept |
+-----+
```

In Figure 2, we are using IfCap1 to indicate interface type with capability set 1 handling ingress flow for functional roles of "A+B". We are using classifier for departments to lead us into the Classifier Example below.

2. Classifier and Classifier Element Example

We want to show how a multilevel classifier can be built using the classifier tables provided by this PIB. Notice we didn't go into details on the filters because they are not defined by this PIB. Continuing in the Data Path example from the previous section, let's say we want to perform the following classification functionality to do flow separation based on department and application type:

```

if (Dept1) then take Dept1-action
{
  if (Appl1) then take Dept1-Appl1-action.
  if (Appl2) then take Dept1-Appl2-action.
  if (Appl3) then take Dept1-Appl3-action.
}
if (Dept2) then take Dept2-action
{
  if (Appl1) then take Dept2-Appl1-action.
  if (Appl2) then take Dept2-Appl2-action.
  if (Appl3) then take Dept2-Appl3-action.
}
if (Dept3) then take Dept3-action
{
  if (Appl1) then take Dept3-Appl1-action.
  if (Appl2) then take Dept3-Appl2-action.
  if (Appl3) then take Dept3-Appl3-action.
}

```

The above classification logic is translated into the following PIB table entries, with two levels of classifications.

First for department:

```
+-----+
|Clfr    |
| Id=Dept |
+-----+
```

```
+-----+ +-----+
|ClfrElement | +-->|Clfr    |
| Id=Dept1    | |   | Id=D1Appl |
| ClfrId=Dept | |   +-----+
| Preced=NA   | |
| Next -----+--+ +-----+
| Specific ---+----->|Filter Dept1|
+-----+ +-----+
```

```
+-----+ +-----+
|ClfrElement | +-->|Clfr    |
| Id=Dept2    | |   | Id=D2Appl |
| ClfrId=Dept | |   +-----+
| Preced=NA   | |
| Next -----+--+ +-----+
| Specific ---+----->|Filter Dept2|
+-----+ +-----+
```

```
+-----+ +-----+
|ClfrElement | +-->|Clfr    |
| Id=Dept3    | |   | Id=D3Appl |
| ClfrId=Dept | |   +-----+
| Preced=NA   | |
| Next -----+--+ +-----+
| Specific ---+----->|Filter Dept3|
+-----+ +-----+
```

Second for application:

```
+-----+
|Clfr    |
|        |
```

```

| Id=D1Appl |
+-----+

+-----+
|ClfrElement | +----->|Meter |
| Id=D1Appl1 | | | Id=D1A1Rate1 |
| ClfrId=D1Appl | | | SucceedNext -+--->...
| Preced=NA | | | FailNext ----+--->...
| Next -----+--+ +-----+ | Specific ----+--->...
| Specific -----+--->|Filter Appl1| +-----+
+-----+ +-----+

+-----+
|ClfrElement | +----->|Meter |
| Id=D1Appl2 | | | Id=D1A2Rate1 |
| ClfrId=D1Appl | | | SucceedNext -+--->...
| Preced=NA | | | FailNext ----+--->...
| Next -----+--+ +-----+ | Specific ----+--->...
| Specific -----+--->|Filter Appl2| +-----+
+-----+ +-----+

+-----+
|ClfrElement | +----->|Meter |
| Id=D1Appl3 | | | Id=D1A3Rate1 |
| ClfrId=D1Appl | | | SucceedNext -+--->...
| Preced=NA | | | FailNext ----+--->...
| Next -----+--+ +-----+ | Specific ----+--->...
| Specific -----+--->|Filter Appl3| +-----+
+-----+ +-----+

```

Figure 3: Classifier Usage Example

The application classifiers for department 2 and 3 will be very much like the application classifier for department 1 shown above. Notice in this example, Filters for Appl1, Appl2, and Appl3 are reusable across the application classifiers.

This classifier and classifier element example assume the next differentiated services functional datapath element is Meter and leads us into the Meter Example section.

3. Meter Example

A single rate simple Meter may be easy to envision, hence we will do a Two Rate Three Color [TRTCM] example, using two Meter table entries and two TBParam table entries.

```

+-----+ +-----+ +-----+ +-----+
|Meter | +->|Action | +->|Meter | +->|Action |
| Id=D1A1Rate1 | | | Id=Green | | | Id=D1A1Rate2 | | | Id=Yellow |
| SucceedNext -++ +-----+ | | SucceedNext -++ +-----+
| FailNext ----+-----+ | | FailNext ----+---+ +-----+

```


above for AF11 flow. We will provide three different dropper setups, from simple to complex. The examples below may include some queuing structures; they are here only to show the relationship of the droppers to queuing and are not complete. Queuing examples are provided in later sections.

5.1. Tail Dropper Example

The Tail Dropper is one of the simplest. For this example we just want to drop part of the flow that exceeds the queue's buffering capacity, 2 Mbytes.

```

+-----+          +-----+
|AlgDrop      |      +-->|Q AF1 |
| Id=AF11     |      | +-----+
| Type=tailDrop |      |
| Next -----+-----+
| QMeasure -----+--+
| QThreshold=2Mbytes |
| Specific=0.0      |
+-----+

```

Figure 6: Tail Dropper Usage Example

5.2. Single Queue Random Dropper Example

The use of Random Dropper will introduce the usage of dsRandomDropEntry as in the example below.

```

+-----+          +-----+
|AlgDrop      |      +-->|Q AF1 |
| Id=AF11     |      | +-----+
| Type=randomDrop |      |
| Next -----+-----+
| QMeasure -----+--+
| QThreshold    | +-----+
| Specific -----+-->|RandomDrop |
+-----+          | MinThreshBytes |
                    | MinThreshPkts |
                    | MaxThreshBytes |
                    | MaxThreshPkts |
                    | ProbMax        |
                    | Weight         |
                    | SamplingRate   |
                    +-----+

```

Figure 7: Single Queue Random Dropper Usage Example

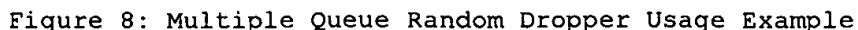
Notice for Random Dropper, dsAlgDropQThreshold contains the maximum

5.3. Multiple Queue Random Dropper Example

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For this example, we have two queues, Q_AF1 and Q_AF2, sharing the same buffer resources. We want to make sure the common buffer resource is sufficient to service the AF11 traffic, and we want to measure the two queues for determining the drop algorithm for AF11 traffic feeding into Q_AF1. Notice mQDrop is used for dsAlgDropType of dsAlgDropEntry to indicate Multiple Queue Dropping Algorithm.

The common shared buffer resource is indicated by the use of dsAlgDropEntry, with their attributes used as follows:

- dsAlgDropType indicates the algorithm used, mQDrop.
- dsAlgDropNext is used to indicate the next functional data path element to handle the flow when no drop occurs.
- dsAlgDropQMeasure is used as the anchor for the list of dsMQAlgDropEntry, one for each queue being measured.

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- dsAlgDropQThreshold is used to indicate the size of the shared buffer pool.
- dsAlgDropSpecific can be used to reference instances of additional PRC (not defined in this PIB) if more parameters are required to describe the common shared buffer resource.

For this example, there are two subsequent dsMQAlgDropEntrys, one for each queue being measured, with its attributes used as follows:

- dsMQAlgDropType indicates the algorithm used, for this example, both dsMQAlgDropType uses randomDrop.
- dsMQAlgDropQMeasure indicates the queue being measured.
- dsMQAlgDropNext indicates the next functional data path element to handle the flow when no drop occurs.
- dsMQAlgDropExceedNext is used to indicate the next queue's dsMQAlgDropEntry. With the use of zeroDotZero to indicate the last queue.
- dsMQAlgDropQMeasure is used to indicate the queue being measured. For this example, Q_AF1 and Q_AF2 are the two queues used.
- dsAlgDropQThreshold is used as in single queue Random Dropper.
- dsAlgDropSpecific is used to reference the PRID that describes the dropper parameters as in its normal usage. For this example both dsAlgDropSpecifics reference dsRandomDropEntrys.

Notice the anchoring dsAlgDropEntry and the two dsMQAlgDropEntrys all have their Next attribute pointing to Q_AF1. This indicates:

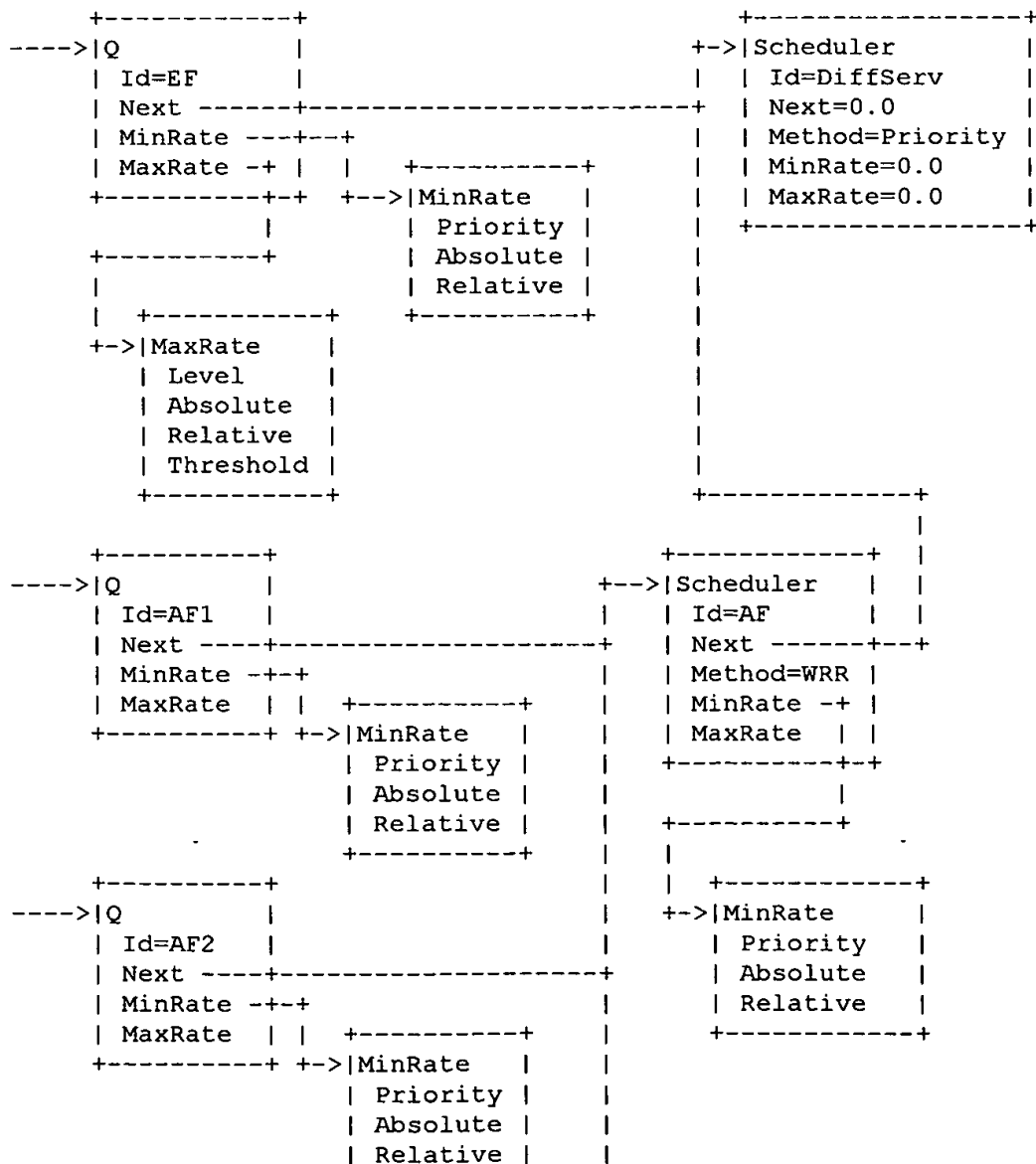
- If the packet does not need to be checked with the individual queue's drop processing because of abundance of common shared buffer resources, then the packet is sent to Q_AF1.
- If the packet is not dropped due to current Q_AF1 conditions, then it is sent to Q_AF1.
- If the packet is not dropped due to current Q_AF2 conditions, then it is sent to Q_AF1.

This example also uses two dsRandomDropEntrys for the two queues it measures. Their attribute usage is the same as if for single queue random dropper.

Other more complex result combinations can be achieved by specifying a new PRC and referencing this new PRC with the dsAlgDropSpecific of the anchoring dsAlgDropEntry. A more simple usage can also be achieved when a single set of drop parameters are used for all queues being measured. This, again, can be referenced by the anchoring of dsAlgDropSpecific. These are not defined in this PIB.

6. Queue and Scheduler Example

The queue and scheduler example will continue from the dropper example in the previous section, concentrating in the queue and scheduler DiffServ datapath functional elements. Notice a shaper is constructed using queue and scheduler with MaxRate parameters.



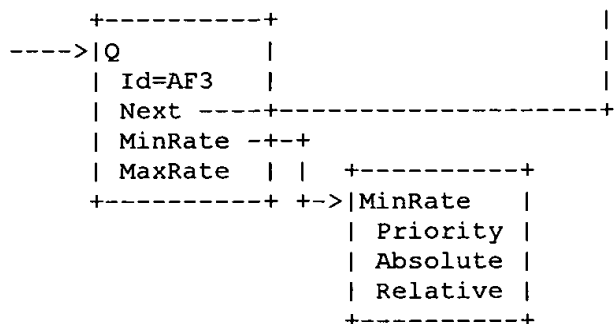


Figure 9: Queue and Scheduler Usage Example

This example shows the queuing system for handling EF, AF1, AF2, and AF3 traffic. It is assumed that AF11, AF12, and AF13 traffic feeds into Queue AF1. And likewise for AF2x and AF3x traffic.

The AF1, AF2, and AF3 Queues are serviced by the AF Scheduler using a Weighed Round Robin method. The AF Scheduler will service each of the queues feeding into it based on the minimum rate parameters of each queue.

The AF and EF traffic are serviced by the DiffServ Scheduler using a Strict Priority method. The DiffServ Scheduler will service each of its inputs based on their priority parameter.

Notice there is an upper bound to the servicing of EF traffic by the DiffServ Scheduler. This is accomplished with the use of maximum rate parameters. The DiffServ Scheduler uses both the maximum rate and priority parameters when servicing the EF Queue.

The DiffServ Scheduler is the last DiffServ datapath functional element in this datapath. It uses zeroDotZero in its Next attribute.

Summary of the DiffServ PIB

The DiffServ PIB consists of one module containing the base PRCs for setting DiffServ policy, queues, classifiers, meters, etc., and also contains capability PRC's that allow a PEP to specify its device characteristics to the PDP. This module contains two groups that are summarized in this section.

DiffServ Capabilities Group

This group consists of PRCs to indicate to the PDP the types of interface supported on the PEP in terms of their DiffServ capabilities and PRCs that the PDP can install in order to configure these interfaces (queues, scheduling parameters, buffer

sizes, etc.) to affect the desired policy. This group describes capabilities in terms of the types of interfaces and takes configuration in terms of interface types and role combinations [FR-PIB]; it does not deal with individual interfaces on the device.

DiffServ Policy Group

This group contains configurations of the functional elements that comprise the DiffServ policy that applies to an interface and the specific parameters that describe those elements. This group contains classifiers, meters, actions, droppers, queues and schedulers. This group also contains the PRC that associates the datapath elements with role combinations.

PIB Operational Overview

This section provides an operational overview of configuring DiffServ QoS policy.

After the initial PEP to PDP communication setup, using [COPS-PR] for example, the PEP will provide to the PDP the PIB Provisioning classes (PRCs), interface types, and interface type capabilities it supports.

The PRCs supported by the PEP are reported to the PDP in the PRC Support Table, `frwkPrcSupportTable`, defined in the framework PIB [FR-PIB]. Each instance of the `frwkPrcSupportTable` indicates a PRC that the PEP understands and for which the PDP can send class instances as part of the policy information.

The capabilities of interface types the PEP supports are described by rows in the capability set table, `frwkCapabilitySetTable`. Each row, or instance of this class contains a pointer to an instance of a PRC that describes the capabilities of the interface type. The capability objects may reside in the `dsIfClassifierCapsTable`, the `dsIfMeteringCapsTable`, the `dsIfSchedulerCapsTable`, the `dsIfElmDepthCapsTable`, the `dsIfElmLinkCapsTable`, or in a table defined in another PIB.

The PDP, with knowledge of the PEP's capabilities, then provides the PEP with administrative domain and interface-type-specific policy information.

Instances of the `dsDataPathTable` are used to specify the first element in the set of functional elements applied to an interface type. Each instance of the `dsDataPathTable` applies to an interface type defined by its roles and direction (ingress or egress).

PIB Definition

```
FFSERV-PIB PIB-DEFINITIONS ::= BEGIN
```

PORTS

Unsigned32, MODULE-IDENTITY, MODULE-COMPLIANCE,
OBJECT-TYPE, OBJECT-GROUP, pib
FROM COPS-PR-SPPI
InstanceId, Prid, TagId, TagReferenceId
FROM COPS-PR-SPPI-TC
zeroDotZero
FROM SNMPv2-SMI
AutonomousType
FROM SNMPv2-TC
SnmpAdminString
FROM SNMP-FRAMEWORK-MIB
RoleCombination, PrcIdentifierOid, PrcIdentifierOidOrZero,
AttrIdentifier
FROM FRAMEWORK-TC-PIB
Dscp
FROM DIFFSERV-DSCP-TC
IfDirection
FROM DIFFSERV-MIB
BurstSize
FROM INTEGRATED-SERVICES-MIB;

PolicyPib MODULE-IDENTITY

SUBJECT-CATEGORIES (diffServ (2)) -- DiffServ QoS COPS Client Type
LAST-UPDATED "200302180000Z" -- 18 Feb 2003
ORGANIZATION "IETF DIFFSERV WG"
CONTACT-INFO "

Keith McCloghrie
Cisco Systems, Inc.
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San Jose, CA 95134-1706 USA
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Nortel Networks, Inc.

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Billerica, MA 01821 USA
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Differentiated Services Working Group:
diffserv@ietf.org"

DESCRIPTION

"The PIB module containing a set of provisioning classes
that describe quality of service (QoS) policies for
DiffServ. It includes general classes that may be extended

by other PIB specifications as well as a set of PIB classes related to IP processing.

Copyright (C) The Internet Society (2003). This version of this PIB module is part of RFC 3317; see the RFC itself for full legal notices."

REVISION "200302180000Z" -- 18 Feb 2003

DESCRIPTION

"Initial version, published as RFC 3317."

::= { pib 4 }

CapabilityClasses OBJECT IDENTIFIER ::= { dsPolicyPib 1 }

PolicyClasses OBJECT IDENTIFIER ::= { dsPolicyPib 2 }

PolicyPibConformance OBJECT IDENTIFIER ::= { dsPolicyPib 3 }

Interface Type Capabilities Group

Interface Type Capability Tables

The Interface type capability tables define capabilities that may be associated with interfaces of a specific type.

This PIB defines capability tables for DiffServ Functionalities.

The Base Capability Table

BaseIfCapsTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsBaseIfCapsEntry

PIB-ACCESS notify

STATUS current

DESCRIPTION

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"The Base Interface Type Capability class. This class represents a generic capability supported by a device in the ingress, egress, or both directions."

::= { dsCapabilityClasses 1 }

BaseIfCapsEntry OBJECT-TYPE

SYNTAX DsBaseIfCapsEntry

STATUS current

DESCRIPTION

"An instance of this class describes the dsBaseIfCaps class."

PIB-INDEX { dsBaseIfCapsPrid }

= { dsBaseIfCapsTable 1 }

BaseIfCapsEntry ::= SEQUENCE {

dsBaseIfCapsPrid InstanceId,

dsBaseIfCapsDirection INTEGER

BaseIfCapsPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an instance of the class."

::= { dsBaseIfCapsEntry 1 }

BaseIfCapsDirection OBJECT-TYPE

SYNTAX INTEGER {
inbound(1),
outbound(2),
inAndOut(3)
}

STATUS current

DESCRIPTION

"This object specifies the direction(s) for which the capability applies. A value of 'inbound(1)' means the capability applies only to the ingress direction. A value of 'outbound(2)' means the capability applies only to the egress direction. A value of 'inAndOut(3)' means the capability applies to both directions."

::= { dsBaseIfCapsEntry 2 }

The Classification Capability Table

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IfClassificationCapsTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsIfClassificationCapsEntry

PIB-ACCESS notify

STATUS current

DESCRIPTION

"This class specifies the classification capabilities of a Capability Set."

::= { dsCapabilityClasses 2 }

IfClassificationCapsEntry OBJECT-TYPE

SYNTAX DsIfClassificationCapsEntry

STATUS current

DESCRIPTION

"An instance of this class describes the classification capabilities of a Capability Set."

EXTENDS { dsBaseIfCapsEntry }

UNIQUENESS { dsBaseIfCapsDirection,
dsIfClassificationCapsSpec }

::= { dsIfClassificationCapsTable 1 }

IfClassificationCapsEntry ::= SEQUENCE {

dsIfClassificationCapsSpec BITS

IfClassificationCapsSpec OBJECT-TYPE

```
SYNTAX      BITS {
    ipSrcAddrClassification(0),
    -- indicates the ability to classify based on
    -- IP source addresses
    ipDstAddrClassification(1),
    -- indicates the ability to classify based on
    -- IP destination addresses
    ipProtoClassification(2),
    -- indicates the ability to classify based on
    -- IP protocol numbers
    ipDscpClassification(3),
    -- indicates the ability to classify based on
    -- IP DSCP
    ipL4Classification(4),
    -- indicates the ability to classify based on
    -- IP layer 4 port numbers for UDP and TCP
    ipV6FlowID(5),
    -- indicates the ability to classify based on
    -- IPv6 FlowIDs.
}
```

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STATUS current

DESCRIPTION

"Bit set of supported classification capabilities. In addition to these capabilities, other PIBs may define other capabilities that can then be specified in addition to the ones specified here (or instead of the ones specified here if none of these are specified)."

::= { dsIfClassificationCapsEntry 1 }

Metering Capabilities

IfMeteringCapsTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsIfMeteringCapsEntry

PIB-ACCESS notify

STATUS current

DESCRIPTION

"This class specifies the metering capabilities of a Capability Set."

::= { dsCapabilityClasses 3 }

IfMeteringCapsEntry OBJECT-TYPE

SYNTAX DsIfMeteringCapsEntry

STATUS current

DESCRIPTION

"An instance of this class describes the metering capabilities of a Capability Set."

EXTENDS { dsBaseIfCapsEntry }

UNIQUENESS { dsBaseIfCapsDirection,
 dsIfMeteringCapsSpec }

```
 ::= { dsIfMeteringCapsTable 1 }
```

```
IfMeteringCapsEntry ::= SEQUENCE {  
    dsIfMeteringCapsSpec      BITS
```

IfMeteringCapsSpec OBJECT-TYPE

```
SYNTAX BITS {  
    zeroNotUsed(0),  
    simpleTokenBucket(1),  
    avgRate(2),  
    srTCMBlind(3),  
    srTCMAware(4),  
    trTCMBlind(5),  
    trTCMAware(6),  
    tswTCM(7)
```

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```
    }  
STATUS      current  
DESCRIPTION  
    "Bit set of supported metering capabilities. As with  
    classification capabilities, these metering capabilities may  
    be augmented by capabilities specified in other PRCs (in other  
    PIBs)."  
 ::= { dsIfMeteringCapsEntry 1 }
```

Algorithmic Dropper Capabilities

IfAlgDropCapsTable OBJECT-TYPE

```
SYNTAX      SEQUENCE OF DsIfAlgDropCapsEntry  
PIB-ACCESS  notify  
STATUS      current  
DESCRIPTION  
    "This class specifies the algorithmic dropper  
    capabilities of a Capability Set.
```

This capability table indicates the types of algorithmic drop supported by a Capability Set for a specific flow direction.

Additional capabilities affecting the drop functionalities are determined based on queue capabilities associated with specific instance of a dropper, hence not specified by this class."

```
 ::= { dsCapabilityClasses 4 }
```

IfAlgDropCapsEntry OBJECT-TYPE

```
SYNTAX      DsIfAlgDropCapsEntry  
STATUS      current  
DESCRIPTION
```

"An instance of this class describes the algorithmic dropper capabilities of a Capability Set."

```
EXTENDS { dsBaseIfCapsEntry }
```

```
UNIQUENESS { dsBaseIfCapsDirection,  
             dsIfAlgDropCapType,
```

```

..      dsIfAlgDropCapsMQCount }
::= { dsIfAlgDropCapsTable 1 }

IfAlgDropCapsEntry ::= SEQUENCE {
    dsIfAlgDropCapsType          BITS,
    dsIfAlgDropCapsMQCount      Unsigned32

```

IfAlgDropCapsType OBJECT-TYPE

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```

SYNTAX      BITS {
                zeroNotUsed(0),
                oneNotUsed(1),
                tailDrop(2),
                headDrop(3),
                randomDrop(4),
                alwaysDrop(5),
                mQDrop(6) }
STATUS      current
DESCRIPTION

```

"The type of algorithm that droppers associated with queues may use.

The tailDrop(2) algorithm means that packets are dropped from the tail of the queue when the associated queue's MaxQueueSize is exceeded. The headDrop(3) algorithm means that packets are dropped from the head of the queue when the associated queue's MaxQueueSize is exceeded. The randomDrop(4) algorithm means that an algorithm is executed which may randomly drop the packet, or drop other packet(s) from the queue in its place. The specifics of the algorithm may be proprietary. However, parameters would be specified in the dsRandomDropTable. The alwaysDrop(5) will drop every packet presented to it. The mQDrop(6) algorithm will drop packets based on measurement from multiple queues."

```

::= { dsIfAlgDropCapsEntry 1 }

```

IfAlgDropCapsMQCount OBJECT-TYPE

```

SYNTAX      Unsigned32 (1..4294967295)
STATUS      current
DESCRIPTION

```

"Indicates the number of queues measured for the drop algorithm. This attribute is ignored when alwaysDrop(5) algorithm is used. This attribute contains the value of 1 for all drop algorithm types except for mQDrop(6), where this attribute is used to indicate the maximum number of dsMQAlgDropEntry that can be chained together."

```

::= { dsIfAlgDropCapsEntry 2 }

```

Queue Capabilities

IfQueueCapsTable OBJECT-TYPE

```

SYNTAX      SEQUENCE OF DsIfQueueCapsEntry

```

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STATUS current

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DESCRIPTION

"This class specifies the queueing capabilities of a Capability Set."

::= { dsCapabilityClasses 5 }

IfQueueCapsEntry OBJECT-TYPE

SYNTAX DsIfQueueCapsEntry

STATUS current

DESCRIPTION

"An instance of this class describes the queue capabilities of a Capability Set."

EXTENDS { dsBaseIfCapsEntry }

UNIQUENESS { dsBaseIfCapsDirection,
 dsIfQueueCapsMinQueueSize,
 dsIfQueueCapsMaxQueueSize,
 dsIfQueueCapsTotalQueueSize }

::= { dsIfQueueCapsTable 1 }

IfQueueCapsEntry ::= SEQUENCE {

 dsIfQueueCapsMinQueueSize Unsigned32,

 dsIfQueueCapsMaxQueueSize Unsigned32,

 dsIfQueueCapsTotalQueueSize Unsigned32

IfQueueCapsMinQueueSize OBJECT-TYPE

SYNTAX Unsigned32 (0..4294967295)

UNITS "Bytes"

STATUS current

DESCRIPTION

"Some interfaces may allow the size of a queue to be configured. This attribute specifies the minimum size that can be configured for a queue, specified in bytes.

dsIfQueueCapsMinQueueSize must be less than or equals to dsIfQueueCapsMaxQueueSize when both are specified.

A zero value indicates not specified."

::= { dsIfQueueCapsEntry 1 }

IfQueueCapsMaxQueueSize OBJECT-TYPE

SYNTAX Unsigned32 (0..4294967295)

UNITS "Bytes"

STATUS current

DESCRIPTION

"Some interfaces may allow the size of a queue to be configured. This attribute specifies the maximum size that can be configured for a queue, specified in bytes.

dsIfQueueCapsMinQueueSize must be less than or equals to dsIfQueueCapsMaxQueueSize when both are specified.

A zero value indicates not specified."

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```
::= { dsIfQueueCapsEntry 2 }
```

IfQueueCapsTotalQueueSize OBJECT-TYPE

SYNTAX Unsigned32 (0..4294967295)

UNITS "Bytes"

STATUS current

DESCRIPTION

"Some interfaces may have a limited buffer space to be shared amongst all queues of that interface while also allowing the size of each queue to be configurable. To prevent the situation where the PDP configures the sizes of the queues in excess of the total buffer available to the interface, the PEP can report the total buffer space in bytes available with this capability.

A zero value indicates not specified."

```
::= { dsIfQueueCapsEntry 3 }
```

Scheduler Capabilities

IfSchedulerCapsTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsIfSchedulerCapsEntry

PIB-ACCESS notify

STATUS current

DESCRIPTION

"This class specifies the scheduler capabilities of a Capability Set."

```
::= { dsCapabilityClasses 6 }
```

IfSchedulerCapsEntry OBJECT-TYPE

SYNTAX DsIfSchedulerCapsEntry

STATUS current

DESCRIPTION

"An instance of this class describes the scheduler capabilities of a Capability Set."

EXTENDS { dsBaseIfCapsEntry }

UNIQUENESS { dsBaseIfCapsDirection,
dsIfSchedulerCapsServiceDisc,
dsIfSchedulerCapsMaxInputs }

```
::= { dsIfSchedulerCapsTable 1 }
```

IfSchedulerCapsEntry ::= SEQUENCE {

dsIfSchedulerCapsServiceDisc AutonomousType,

dsIfSchedulerCapsMaxInputs Unsigned32,

dsIfSchedulerCapsMinMaxRate INTEGER

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IfSchedulerCapsServiceDisc OBJECT-TYPE

SYNTAX AutonomousType

STATUS current

DESCRIPTION

• "The scheduling discipline for which the set of capabilities specified in this object apply. Object identifiers for several general purpose and well-known scheduling disciplines are shared with and defined in the DiffServ MIB.

These include diffServSchedulerPriority,
diffServSchedulerWRR, diffServSchedulerWFQ."
::= { dsIfSchedulerCapsEntry 1 }

IfSchedulerCapsMaxInputs OBJECT-TYPE

SYNTAX Unsigned32 (0..4294967295)

STATUS current

DESCRIPTION

"The maximum number of queues and/or schedulers that can feed into a scheduler indicated by this capability entry. A value of zero means there is no maximum."

::= { dsIfSchedulerCapsEntry 2 }

IfSchedulerCapsMinMaxRate OBJECT-TYPE

SYNTAX INTEGER {
minRate(1),
maxRate(2),
minAndMaxRates(3)
}

STATUS current

DESCRIPTION

"Scheduler capability indicating ability to handle inputs with minimum rate, maximum rate, or both."

::= { dsIfSchedulerCapsEntry 3 }

Maximum Rate Capabilities

IfMaxRateCapsTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsIfMaxRateCapsEntry

PIB-ACCESS notify

STATUS current

DESCRIPTION

"This class specifies the maximum rate capabilities of a Capability Set."

::= { dsCapabilityClasses 7 }

IfMaxRateCapsEntry OBJECT-TYPE

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SYNTAX DsIfMaxRateCapsEntry

STATUS current

DESCRIPTION

"An instance of this class describes the maximum rate capabilities of a Capability Set."

EXTENDS { dsBaseIfCapsEntry }

UNIQUENESS { dsBaseIfCapsDirection,
dsIfMaxRateCapsMaxLevels }

::= { dsIfMaxRateCapsTable 1 }

IfMaxRateCapsEntry ::= SEQUENCE {

IfMaxRateCapsMaxLevels OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

STATUS current

DESCRIPTION

"The maximum number of levels a maximum rate specification may have for this Capability Set and flow direction."

::= { dsIfMaxRateCapsEntry 1 }

DataPath Element Linkage Capabilities

DataPath Element Cascade Depth

IfElmDepthCapsTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsIfElmDepthCapsEntry

PIB-ACCESS notify

STATUS current

DESCRIPTION

"This class specifies the number of elements of the same type that can be cascaded together in a datapath."

::= { dsCapabilityClasses 8 }

IfElmDepthCapsEntry OBJECT-TYPE

SYNTAX DsIfElmDepthCapsEntry

STATUS current

DESCRIPTION

"An instance of this class describes the cascade depth for a particular functional datapath element PRC. A functional datapath element not represented in this class can be assumed to have no specific maximum depth."

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EXTENDS { dsBaseIfCapsEntry }

UNIQUENESS { dsBaseIfCapsDirection,
dsIfElmDepthCapsPrc }

::= { dsIfElmDepthCapsTable 1 }

IfElmDepthCapsEntry ::= SEQUENCE {

dsIfElmDepthCapsPrc

PrcIdentifierOid,

dsIfElmDepthCapsCascadeMax

Unsigned32 }

IfElmDepthCapsPrc OBJECT-TYPE

SYNTAX PrcIdentifierOid

STATUS current

DESCRIPTION

"The object identifier of a PRC that represents a functional datapath element. This may be one of: dsClfrElementEntry, dsMeterEntry, dsActionEntry, dsAlgDropEntry, dsQEntry, or dsSchedulerEntry."

* There may not be more than one instance of this class with the same value of dsIfElmDepthCapsPrc and same value of dsBaseIfCapsDirection. Must not contain the value of zeroDotZero."

::= { dsIfElmDepthCapsEntry 1 }

IfElmDepthCapsCascadeMax OBJECT-TYPE

SYNTAX Unsigned32 (0..4294967295)

STATUS current

DESCRIPTION

"The maximum number of elements of type dsIfElmDepthCapsPrc that can be linked consecutively in a data path. A value of zero indicates there is no specific maximum."

::= { dsIfElmDepthCapsEntry 2 }

DataPath Element Linkage Types

IfElmLinkCapsTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsIfElmLinkCapsEntry

PIB-ACCESS notify

STATUS current

DESCRIPTION

"This class specifies what types of datapath functional elements may be used as the next downstream element for a specific type of functional element."

::= { dsCapabilityClasses 9 }

IfElmLinkCapsEntry OBJECT-TYPE

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SYNTAX DsIfElmLinkCapsEntry

STATUS current

DESCRIPTION

"An instance of this class specifies a PRC that may be used as the next functional element after a specific type of element in a data path."

EXTENDS { dsBaseIfCapsEntry }

UNIQUENESS { dsBaseIfCapsDirection,
dsIfElmLinkCapsPrc,
dsIfElmLinkCapsAttr,
dsIfElmLinkCapsNextPrc }

::= { dsIfElmLinkCapsTable 1 }

IfElmLinkCapsEntry ::= SEQUENCE {

dsIfElmLinkCapsPrc	PrcIdentifierOid,
dsIfElmLinkCapsAttr	AttrIdentifier,
dsIfElmLinkCapsNextPrc	PrcIdentifierOidOrZero

IfElmLinkCapsPrc OBJECT-TYPE

SYNTAX PrcIdentifierOid

STATUS current

DESCRIPTION

" The object identifier of a PRC that represents a functional datapath element. This may be one of: dsClfrElementEntry,

dsMeterEntry, dsActionEntry, dsAlgDropEntry, dsQEntry, or dsSchedulerEntry.

This must not have the value zeroDotZero."

::= { dsIfElmLinkCapsEntry 1 }

IfElmLinkCapsAttr OBJECT-TYPE

SYNTAX AttrIdentifier

STATUS current

DESCRIPTION

"The value represents the attribute in the PRC indicated by dsIfElmLinkCapsPrc that is used to specify the next functional element in the datapath."

::= { dsIfElmLinkCapsEntry 2 }

IfElmLinkCapsNextPrc OBJECT-TYPE

SYNTAX PrcIdentifierOidOrZero

STATUS current

DESCRIPTION

"The value is the OID of a PRC table entry from which instances can be referenced by the attribute indicated by dsIfElmLinkCapsPrc and dsIfElmLinkAttr."

For example, suppose a meter's success output can be an

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action or another meter, and the fail output can only be an action. This can be expressed as follows:

Prid	Prc	Attr	NextPrc
1	dsMeterEntry	dsMeterSucceedNext	dsActionEntry
2	dsMeterEntry	dsMeterSucceedNext	dsMeterEntry
3	dsMeterEntry	dsMeterFailNext	dsActionEntry.

zeroDotZero is a valid value for this attribute to specify that the PRC specified in dsIfElmLinkCapsPrc is the last functional data path element."

::= { dsIfElmLinkCapsEntry 3 }

Policy Classes

Data Path Table

DataPathTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsDataPathEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"The data path table indicates the start of functional data paths in this device."

The Data Path Table enumerates the Differentiated Services Functional Data Paths within this device. Each entry specifies the first functional datapath

* element to process data flow for each specific datapath.
 Each datapath is defined by the interface set's capability
 set name, role combination, and direction. This class can
 therefore have up to two entries for each interface set,
 ingress and egress."
 ::= { dsPolicyClasses 1 }

DataPathEntry OBJECT-TYPE

SYNTAX DsDataPathEntry

STATUS current

DESCRIPTION

"Each entry in this class indicates the start of a single
 functional data path, defined by its capability set name,
 role combination and traffic direction. The first
 functional datapath element to handle traffic for each
 data path is defined by the dsDataPathStart attribute

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of each table entry.

Notice for each entry:

1. dsDataPathCapSetName must reference an existing capability set name in frwkCapabilitySetTable [FR-PIB].
2. dsDataPathRoles must reference existing Role Combination in frwkIfRoleComboTable [FR-PIB].
3. dsDataPathStart must reference an existing entry in a functional data path element table.

If any one or more of these three requirements is not
 satisfied, the dsDataPathEntry will not be installed."

PIB-INDEX { dsDataPathPrid }

UNIQUENESS { dsDataPathCapSetName,
 dsDataPathRoles,
 dsDataPathIfDirection }

::= { dsDataPathTable 1 }

DataPathEntry ::= SEQUENCE {

dsDataPathPrid InstanceId,
 dsDataPathCapSetName SnmpAdminString,
 dsDataPathRoles RoleCombination,
 dsDataPathIfDirection IfDirection,
 dsDataPathStart Prid

DataPathPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an
 instance of the class."

::= { dsDataPathEntry 1 }

DataPathCapSetName OBJECT-TYPE

SYNTAX SnmpAdminString

STATUS current

DESCRIPTION

"The capability set associated with this data path entry.
 The capability set name specified by this attribute
 must exist in the frwkCapabilitySetTable [FR-PIB]

" prior to association with an instance of this class."
::= { dsDataPathEntry 2 }

DataPathRoles OBJECT-TYPE

SYNTAX RoleCombination

STATUS current

DESCRIPTION

"The interfaces to which this data path entry applies,
specified in terms of roles. There must exist an entry

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in the frwkIfRoleComboTable [FR-PIB] specifying
this role combination, together with the capability
set specified by dsDataPathCapSetName, prior to
association with an instance of this class."

::= { dsDataPathEntry 3 }

DataPathIfDirection OBJECT-TYPE

SYNTAX IfDirection

STATUS current

DESCRIPTION

"Specifies the direction for which this data path
entry applies."

::= { dsDataPathEntry 4 }

DataPathStart OBJECT-TYPE

SYNTAX Prid

STATUS current

DESCRIPTION

"This selects the first functional datapath element
to handle traffic for this data path. This
Prid should point to an instance of one of:

dsClfrEntry
dsMeterEntry
dsActionEntry
dsAlgDropEntry
dsQEntry

The PRI pointed to must exist prior to the installation of
this datapath start element."

::= { dsDataPathEntry 5 }

Classifiers

Classifier allows multiple classifier elements, of same or
different types, to be used together.

A classifier must completely classify all packets presented to
it. This means all traffic handled by a classifier must match
at least one classifier element within the classifier,
with the classifier element parameters specified by a filter.
It is the PDP's responsibility to create a _catch all_ classifier
element and filter that matches all packet. This _catch all_
classifier element should have the lowest Precedence value.

If there is ambiguity between classifier elements of different
classifier, classifier linkage order indicates their precedence;

the first classifier in the link is applied to the traffic first.

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Each entry in the classifier table represents a classifier, with classifier element table handling the fan-out functionality of a classifier, and filter table defining the classification patterns.

Classifier Table

ClfrTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsClfrEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"This table enumerates all the DiffServ classifier functional data path elements of this device. The actual classification definitions are detailed in dsClfrElementTable entries belonging to each classifier. Each classifier is referenced by its classifier elements using its classifier ID.

An entry in this table, referenced by an upstream functional data path element or a datapath table entry, is the entry point to the classifier functional data path element.

The dsClfrId of each entry is used to organize all classifier elements belonging to the same classifier."

REFERENCE

"An Informal Management Model for Diffserv Routers,
RFC 3290, section 4.1"

::= { dsPolicyClasses 2 }

ClfrEntry OBJECT-TYPE

SYNTAX DsClfrEntry

STATUS current

DESCRIPTION

"An entry in the classifier table describes a single classifier. Each classifier element belonging to this classifier must have its dsClfrElementClfrId attribute equal to dsClfrId."

PIB-INDEX { dsClfrPrid }

UNIQUENESS { dsClfrId }

::= { dsClfrTable 1 }

ClfrEntry ::= SEQUENCE {

dsClfrPrid InstanceId,

dsClfrId TagReferenceId

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ClfrPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an instance of the class."

```
::= { dsClfrEntry 1 }
```

ClfrId OBJECT-TYPE

SYNTAX TagReferenceId

PIB-TAG { dsClfrElementClfrId }

STATUS current

DESCRIPTION

"Identifies a Classifier. A Classifier must be complete, this means all traffic handled by a Classifier must match at least one Classifier Element within the Classifier."

```
::= { dsClfrEntry 2 }
```

Classifier Element Table

ClfrElementTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsClfrElementEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"Entries in the classifier element table serves as the anchor for each classification pattern, defined in filter table entries. Each classifier element table entry also specifies the subsequent downstream diffserv functional datapath element when the classification pattern is satisfied. Hence the classifier element table enumerates the relationship between classification patterns and subsequent downstream diffserv functional data path elements, describing one branch of the fan-out characteristic of a classifier indicated in [Model].

Classification parameters are defined by entries of filter tables pointed to by dsClfrElementSpecific. There can be filter tables of different types, and they can be inter-mixed and used within a classifier. An example of a filter table is the frwkIpFilterTable [FR-PIB], for IP Multi-Field Classifiers (MFCs).

If there is ambiguity between classifier elements of the same classifier, then dsClfrElementPrecedence needs to be used."

```
::= { dsPolicyClasses 3 }
```

ClfrElementEntry OBJECT-TYPE

SYNTAX DsClfrElementEntry

STATUS current

DESCRIPTION

"An entry in the classifier element table describes a single element of the classifier."

PIB-INDEX { dsClfrElementPrid }

UNIQUENESS { dsClfrElementClfrId,
dsClfrElementPrecedence,
dsClfrElementSpecific }

::= { dsClfrElementTable 1 }

ClfrElementEntry ::= SEQUENCE {

dsClfrElementPrid InstanceId,

dsClfrElementClfrId TagId,

dsClfrElementPrecedence Unsigned32,

dsClfrElementNext Prid,

dsClfrElementSpecific Prid

ClfrElementPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an instance of the class."

::= { dsClfrElementEntry 1 }

ClfrElementClfrId OBJECT-TYPE

SYNTAX TagId

STATUS current

DESCRIPTION

"A classifier is composed of one or more classifier elements. Each classifier element belonging to the same classifier uses the same classifier ID.

Hence, A classifier Id identifies which classifier this classifier element is a part of. This must be the value of dsClfrId attribute for an existing instance of dsClfrEntry."

::= { dsClfrElementEntry 2 }

ClfrElementPrecedence OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

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STATUS current

DESCRIPTION

"The relative order in which classifier elements are applied: higher numbers represent classifier elements with higher precedence. Classifier elements with the same precedence must be unambiguous i.e., they must define non-overlapping patterns, and are considered to be applied simultaneously to the traffic stream. Classifier elements with different precedence may overlap in their filters: the classifier element with the highest precedence that matches is taken.

On a given interface, there must be a complete classifier in place at all times in the ingress direction. This means that there will always be one or more filters that match every possible pattern that could be presented in an incoming packet. There is no such requirement in the egress direction."

```
 ::= { dsClfrElementEntry 3 }
```

ClfrElementNext OBJECT-TYPE

SYNTAX Prid
STATUS current
DESCRIPTION

"This attribute provides one branch of the fan-out functionality of a classifier described in DiffServ Model section 4.1.

This selects the next diffserv functional datapath element to handle traffic for this data path.

A value of zeroDotZero marks the end of DiffServ processing for this data path. Any other value must point to a valid (pre-existing) instance of one of:

dsClfrEntry
dsMeterEntry
dsActionEntry
dsAlgDropEntry
dsQEntry."

DEFVAL { zeroDotZero }
 ::= { dsClfrElementEntry 4 }

ClfrElementSpecific OBJECT-TYPE

SYNTAX Prid
STATUS current
DESCRIPTION

"A pointer to a valid entry in another table that describes the applicable classification filter, e.g.,

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an entry in frwkIpFilterTable (Framework PIB).

The PRI pointed to must exist prior to the installation of this classifier element.

The value zeroDotZero is interpreted to match anything not matched by another classifier element - only one such entry may exist for each classifier."

```
 ::= { dsClfrElementEntry 5 }
```

Meters

This PIB supports a variety of Meters. It includes a specific definition for Meters whose parameter set can be modeled using Token Bucket parameters. Other metering parameter sets can be defined by other PIBs.

Multiple meter elements may be logically cascaded using their dsMeterSucceedNext and dsMeterFailNext pointers if required.

One example of this might be for an AF PHB implementation that uses multiple level conformance meters.

Cascading of individual meter elements in the PIB is intended to be functionally equivalent to multiple level conformance determination of a packet. The sequential nature of the representation is merely a notational convenience for this PIB.

srTCM meters (RFC 2697) can be specified using two sets of dsMeterEntry and dsTBParamEntry. First set specifies the Committed Information Rate and Committed Burst Size token-bucket. Second set specifies the Excess Burst Size token-bucket.

trTCM meters (RFC 2698) can be specified using two sets of dsMeterEntry and dsTBParamEntry. First set specifies the Committed Information Rate and Committed Burst Size token-bucket. Second set specifies the Peak Information Rate and Peak Burst Size token-bucket.

tswTCM meters (RFC 2859) can be specified using two sets of dsMeterEntry and dsTBParamEntry. First set specifies the Committed Target Rate token-bucket. Second set specifies the Peak Target Rate token-bucket. dsTBParamInterval in each token bucket reflects the Average Interval.

MeterTable OBJECT-TYPE

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SYNTAX SEQUENCE OF DsMeterEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"This class enumerates specific meters that a system may use to police a stream of traffic. The traffic stream to be metered is determined by the element(s) upstream of the meter i.e., by the object(s) that point to each entry in this class. This may include all traffic on an interface.

Specific meter details are to be found in table entry referenced by dsMeterSpecific."

REFERENCE

"An Informal Management Model for Diffserv Routers, RFC 3290, section 5"

::= { dsPolicyClasses 4 }

MeterEntry OBJECT-TYPE

SYNTAX DsMeterEntry

STATUS current

DESCRIPTION

"An entry in the meter table describes a single conformance level of a meter."

PIB-INDEX { dsMeterPrid }

```

UNIQUENESS { dsMeterSucceedNext,
              dsMeterFailNext,
              dsMeterSpecific }
 ::= { dsMeterTable 1 }

```

```

MeterEntry ::= SEQUENCE {
    dsMeterPrid          InstanceId,
    dsMeterSucceedNext   Prid,
    dsMeterFailNext      Prid,
    dsMeterSpecific      Prid
}

```

MeterPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an instance of the class."

```
 ::= { dsMeterEntry 1 }
```

MeterSucceedNext OBJECT-TYPE

SYNTAX Prid

STATUS current

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DESCRIPTION

"If the traffic does conform, this selects the next diffserv functional datapath element to handle traffic for this data path.

The value zeroDotZero in this variable indicates no further DiffServ treatment is performed on traffic of this datapath. Any other value must point to a valid (pre-existing) instance of one of:

```

    dsClfrEntry
    dsMeterEntry
    dsActionEntry
    dsAlgDropEntry
    dsQEntry."

```

DEFVAL { zeroDotZero }

```
 ::= { dsMeterEntry 2 }
```

MeterFailNext OBJECT-TYPE

SYNTAX Prid

STATUS current

DESCRIPTION

"If the traffic does not conform, this selects the next diffserv functional datapath element to handle traffic for this data path.

The value zeroDotZero in this variable indicates no further DiffServ treatment is performed on traffic of this datapath. Any other value must point to a valid (pre-existing) instance of one of:

```

    dsClfrEntry
    dsMeterEntry
    dsActionEntry

```



```

* PIB-INDEX { dsTBParamPrid }
  UNIQUENESS { dsTBParamType,
               dsTBParamRate,
               dsTBParamBurstSize,
               dsTBParamInterval }
  ::= { dsTBParamTable 1 }

TBParamEntry ::= SEQUENCE {
  dsTBParamPrid      InstanceId,

```

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```

dsTBParamType      AutonomousType,
dsTBParamRate      Unsigned32,
dsTBParamBurstSize BurstSize,
dsTBParamInterval  Unsigned32

```

```

TBParamPrid OBJECT-TYPE
  SYNTAX      InstanceId
  STATUS      current
  DESCRIPTION
    "An arbitrary integer index that uniquely identifies an
     instance of the class."
  ::= { dsTBParamEntry 1 }

```

```

TBParamType OBJECT-TYPE
  SYNTAX      AutonomousType
  STATUS      current
  DESCRIPTION
    "The Metering algorithm associated with the
     Token-Bucket parameters.  zeroDotZero indicates this
     is unknown.

```

Standard values for generic algorithms are as follows:

```

diffServTBParamSimpleTokenBucket, diffServTBParamAvgRate,
diffServTBParamSrTCMblind, diffServTBParamSrTCMAware,
diffServTBParamTrTCMblind, diffServTBParamTrTCMAware,
diffServTBParamTswTCM

```

These are specified in the DiffServ MIB."

```

REFERENCE
  "An Informal Management Model for Diffserv Routers,
   RFC 3290, section 5.1"
  ::= { dsTBParamEntry 2 }

```

```

TBParamRate OBJECT-TYPE
  SYNTAX      Unsigned32 (1..4294967295)
  UNITS       "kilobits per second"
  STATUS      current
  DESCRIPTION
    "The token-bucket rate, in kilobits per second
     (kbps).  This attribute is used for:
     1. CIR in RFC 2697 for srTCM
     2. CIR and PIR in RFC 2698 for trTCM
     3. CTR and PTR in RFC 2859 for TSWTCM
     4. AverageRate in RFC 3290, section 5.1.1"

```

::= { dsTBParamEntry 3 }

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TBParamBurstSize OBJECT-TYPE

SYNTAX BurstSize

UNITS "Bytes"

STATUS current

DESCRIPTION

"The maximum number of bytes in a single transmission burst. This attribute is used for:

1. CBS and EBS in RFC 2697 for srTCM
2. CBS and PBS in RFC 2698 for trTCM
3. Burst Size in RFC 3290, section 5."

::= { dsTBParamEntry 4 }

TBParamInterval OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

UNITS "microseconds"

STATUS current

DESCRIPTION

"The time interval used with the token bucket. For:

1. Average Rate Meter, RFC 3290, section 5.1.1, -Delta.
2. Simple Token Bucket Meter, RFC 3290, section 5.1.3, - time interval t.
3. RFC 2859 TSWTCM, - AVG_INTERVAL.
4. RFC 2697 srTCM, RFC 2698 trTCM, - token bucket update time interval."

::= { dsTBParamEntry 5 }

Actions

The Action Table allows enumeration of the different types of actions to be applied to a traffic flow.

ActionTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsActionEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"The Action Table enumerates actions that can be performed to a stream of traffic. Multiple actions can be concatenated.

Specific actions are indicated by dsAction-Specific which points to an entry of a specific action type parameterizing the action in detail."

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REFERENCE

"An Informal Management Model for Diffserv Routers,
RFC 3290, section 6."

::= { dsPolicyClasses 6 }

ActionEntry OBJECT-TYPE

SYNTAX DsActionEntry

STATUS current

DESCRIPTION

"Each entry in the action table allows description of
one specific action to be applied to traffic."

PIB-INDEX { dsActionPrid }

UNIQUENESS { dsActionNext,
dsActionSpecific }

::= { dsActionTable 1 }

ActionEntry ::= SEQUENCE {

dsActionPrid InstanceId,

dsActionNext Prid,

dsActionSpecific Prid

ActionPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an
instance of the class."

::= { dsActionEntry 1 }

ActionNext OBJECT-TYPE

SYNTAX Prid

STATUS current

DESCRIPTION

"This selects the next diffserv functional datapath
element to handle traffic for this data path.

The value zeroDotZero in this variable indicates no
further DiffServ treatment is performed on traffic of
this datapath. Any other value must point to a valid
(pre-existing) instance of one of:

dsClfrEntry
dsMeterEntry
dsActionEntry
dsAlgDropEntry
dsQEntry."

DEFVAL { zeroDotZero }

::= { dsActionEntry 2 }

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ActionSpecific OBJECT-TYPE

SYNTAX Prid

STATUS current

• DESCRIPTION

"A pointer to an object instance providing additional information for the type of action indicated by this action table entry.

For the standard actions defined by this PIB module, this should point to an instance of dsDscpMarkActEntry. For other actions, it may point to an instance of a PRC defined in some other PIB.

The PRI pointed to must exist prior to installing this action datapath entry."

::= { dsActionEntry 3 }

DSCP Mark Action Table

Rows of this class are pointed to by dsActionSpecific to provide detailed parameters specific to the DSCP Mark action.

This class should at most contain one entry for each supported DSCP value. These entries should be reused by different dsActionEntry in same or different data paths.

DscpMarkActTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsDscpMarkActEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"This class enumerates specific DSCPs used for marking or remarking the DSCP field of IP packets. The entries of this table may be referenced by a dsActionSpecific attribute."

REFERENCE

"An Informal Management Model for Diffserv Routers, RFC 3290, section 6.1"

::= { dsPolicyClasses 7 }

DscpMarkActEntry OBJECT-TYPE

SYNTAX DsDscpMarkActEntry

STATUS current

DESCRIPTION

"An entry in the DSCP mark action table that describes a single DSCP used for marking."

PIB-INDEX { dsDscpMarkActPrid }

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UNIQUENESS { dsDscpMarkActDscp }

::= { dsDscpMarkActTable 1 }

DscpMarkActEntry ::= SEQUENCE {

dsDscpMarkActPrid InstanceId,

dsDscpMarkActDscp Dscp

DscpMarkActPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an instance of the class."

::= { dsDscpMarkActEntry 1 }

DscpMarkActDscp OBJECT-TYPE

SYNTAX Dscp
STATUS current

DESCRIPTION

"The DSCP that this Action uses for marking/remarking traffic. Note that a DSCP value of -1 is not permitted in this class. It is quite possible that the only packets subject to this Action are already marked with this DSCP. Note also that DiffServ may result in packet remarking both on ingress to a network and on egress from it and it is quite possible that ingress and egress would occur in the same router."

::= { dsDscpMarkActEntry 2 }

Algorithmic Drop Table

Algorithmic Drop Table is the entry point for the Algorithmic Dropper functional data path element.

For a simple algorithmic dropper, a single algorithmic drop entry will be sufficient to parameterize the dropper.

For more complex algorithmic dropper, the dsAlgDropSpecific attribute can be used to reference an entry in a parameter table, e.g., dsRandomDropTable for random dropper.

For yet more complex dropper, for example, dropper that measures multiple queues, each queue with its own algorithm, can use a dsAlgDropTable entry as the entry point for Algorithmic Dropper

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functional data path element, leaving the dropper parameters for each queue be specified by entries of dsMQAlgDropTable. In such usage, the anchoring dsAlgDropEntry's dsAlgDropType should be mQDrop, and its dsAlgDropQMeasure should reference the subsequent dsMQAlgDropEntry's, its dsAlgDropSpecific should be used to reference parameters applicable to all the queues being measured.

The subsequent dsMQAlgDropEntry's will provide the parameters, one for each queue being measured. The dsMQAlgDropEntry's are chained using their dsMQAlgDropNext attributes.

AlgDropTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsAlgDropEntry
PIB-ACCESS install
STATUS current

DESCRIPTION

"The algorithmic drop table contains entries describ-

ing a functional data path element that drops packets according to some algorithm."

REFERENCE

"An Informal Management Model for Diffserv Routers,
RFC 3290, section 7.1.3"

::= { dsPolicyClasses 8 }

AlgDropEntry OBJECT-TYPE

SYNTAX DsAlgDropEntry

STATUS current

DESCRIPTION

"An entry describes a process that drops packets according to some algorithm. Further details of the algorithm type are to be found in dsAlgDropType and with more detail parameter entry pointed to by dsAlgDropSpecific when necessary."

PIB-INDEX { dsAlgDropPrid }

UNIQUENESS { dsAlgDropType,
dsAlgDropNext,
dsAlgDropQMeasure,
dsAlgDropQThreshold,
dsAlgDropSpecific }

::= { dsAlgDropTable 1 }

AlgDropEntry ::= SEQUENCE {

dsAlgDropPrid InstanceId,
dsAlgDropType INTEGER,
dsAlgDropNext Prid,
dsAlgDropQMeasure Prid,
dsAlgDropQThreshold Unsigned32,

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dsAlgDropSpecific

Prid

AlgDropPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an instance of the class."

::= { dsAlgDropEntry 1 }

AlgDropType OBJECT-TYPE

SYNTAX INTEGER {
other(1),
tailDrop(2),
headDrop(3),
randomDrop(4),
alwaysDrop(5),
mqDrop(6)
}

STATUS current

DESCRIPTION

"The type of algorithm used by this dropper. A value of tailDrop(2), headDrop(3), or alwaysDrop(5) represents an algorithm that is completely specified by this PIB."

A value of other(1) indicates that the specifics of the drop algorithm are specified in some other PIB module, and that the dsAlgDropSpecific attribute points to an instance of a PRC in that PIB that specifies the information necessary to implement the algorithm.

The tailDrop(2) algorithm is described as follows: dsAlgDropQThreshold represents the depth of the queue, pointed to by dsAlgDropQMeasure, at which all newly arriving packets will be dropped.

The headDrop(3) algorithm is described as follows: if a packet arrives when the current depth of the queue, pointed to by dsAlgDropQMeasure, is at dsAlgDropQThreshold, packets currently at the head of the queue are dropped to make room for the new packet to be enqueued at the tail of the queue.

The randomDrop(4) algorithm is described as follows: on packet arrival, an algorithm is executed which may randomly drop the packet, or drop other packet(s)

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from the queue in its place. The specifics of the algorithm may be proprietary. For this algorithm, dsAlgDropSpecific points to a dsRandomDropEntry that describes the algorithm. For this algorithm, dsAlgQThreshold is understood to be the absolute maximum size of the queue and additional parameters are described in dsRandomDropTable.

The alwaysDrop(5) algorithm always drops packets. In this case, the other configuration values in this Entry are not meaningful; The queue is not used, therefore, dsAlgDropNext, dsAlgDropQMeasure, and dsAlgDropSpecific should be all set to zeroDotZero.

The mQDrop(6) algorithm measures multiple queues for the drop algorithm. The queues measured are represented by having dsAlgDropQMeasure referencing a dsMQAlgDropEntry. Each of the chained dsMQAlgDropEntry is used to describe the drop algorithm for one of the measured queues."

::= { dsAlgDropEntry 2 }

AlgDropNext OBJECT-TYPE

SYNTAX Prid

STATUS current

DESCRIPTION

"This selects the next diffserv functional datapath element to handle traffic for this data path.

The value zeroDotZero in this attribute indicates no further DiffServ treatment is performed on traffic of this datapath. Any other value must point to a valid

(pre-existing) instance of one of:

- dsClfrEntry
- dsMeterEntry
- dsActionEntry
- dsAlgDropEntry
- dsQEntry.

When dsAlgDropType is alwaysDrop(5), this attribute is Ignored."

```
DEFVAL      { zeroDotZero }  
::= { dsAlgDropEntry 3 }
```

AlgDropQMeasure OBJECT-TYPE

```
SYNTAX      Prid  
STATUS      current  
DESCRIPTION
```

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"Points to a PRI to indicate the queues that a drop algorithm is to monitor when deciding whether to drop a packet.

For alwaysDrop(5), this attribute should be zeroDotZero.
For tailDrop(2), headDrop(3), randomDrop(4), this should point to an entry in the dsQTable.
For mQDrop(6), this should point to a dsMQAlgDropEntry that Describe one of the queues being measured for multiple queue dropper.

The PRI pointed to must exist prior to installing this dropper element."

```
::= { dsAlgDropEntry 4 }
```

AlgDropQThreshold OBJECT-TYPE

```
SYNTAX      Unsigned32 (1..4294967295)  
UNITS       "Bytes"  
STATUS      current  
DESCRIPTION
```

"A threshold on the depth in bytes of the queue being measured at which a trigger is generated to the dropping algorithm, unless dsAlgDropType is alwaysDrop(5) where this attribute is ignored.

For the tailDrop(2) or headDrop(3) algorithms, this represents the depth of the queue, pointed to by dsAlgDropQMeasure, at which the drop action will take place. Other algorithms will need to define their own semantics for this threshold."

```
::= { dsAlgDropEntry 5 }
```

AlgDropSpecific OBJECT-TYPE

```
SYNTAX      Prid  
STATUS      current  
DESCRIPTION
```

"Points to a table entry that provides further detail regarding a drop algorithm. The PRI pointed to must exist prior to installing this dropper element.

• Entries with dsAlgDropType equal to other(1) must have this point to an instance of a PRC defined in another PIB module.

Entries with dsAlgDropType equal to random-Drop(4) must have this point to an entry in dsRandomDropTable.

Entries with dsAlgDropType equal to mQDrop(6) can use this

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attribute to reference parameters that is used by all the queues of the multiple queues being measured.

For all other algorithms, this should take the value zeroDotZero."

::= { dsAlgDropEntry 6 }

Multiple Queue Algorithmic Drop Table

Entries of this table should be referenced by dsAlgDropQMeasure when dsAlgDropType is mQDrop(6) for droppers measuring multiple queues for its drop algorithm.

Each entry of the table is used to describe the drop algorithm for a single queue within the multiple queues being measured.

Entries of this table, dsMQAlgDropEntry, is extended from dsAlgDropEntry, with usage of corresponding parameters the same except:

dsAlgDropNext is used to point to the next diffserv functional data path element when the packet is not dropped.

dsMQAlgDropExceedNext is used to point to the next dsMQAlgDropEntry for chaining together the multiple dsMQAlgDropEntry's for the multiple queues being measured.

MQAlgDropTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsmQAlgDropEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"The multiple queue algorithmic drop table contains entries describing each queue being measured for the multiple queue algorithmic dropper."

::= { dsPolicyClasses 9 }

MQAlgDropEntry OBJECT-TYPE

SYNTAX DsmQAlgDropEntry

STATUS current

DESCRIPTION

"An entry describes a process that drops packets according to some algorithm. Each entry is used for each of the multiple queues being measured. Each entry extends the basic dsAlgDropEntry with adding of a dsMQAlgDropExceedNext attribute.

Further details of the algorithm type are to be found in
dsAlgDropType and with more detail parameter entry pointed

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to by dsMQAlgDropSpecific when necessary."

EXTENDS { dsAlgDropEntry }

UNIQUENESS { dsMQAlgDropExceedNext }

::= { dsMQAlgDropTable 1 }

MQAlgDropEntry ::= SEQUENCE {
 dsMQAlgDropExceedNext Prid

MQAlgDropExceedNext OBJECT-TYPE

SYNTAX Prid

STATUS current

DESCRIPTION

"Used for linking of multiple dsMQAlgDropEntry for mQDrop.

A value of zeroDotZero indicates this is the last of a
chain of dsMQAlgDropEntry."

DEFVAL { zeroDotZero }

::= { dsMQAlgDropEntry 1 }

Random Drop Table

RandomDropTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsRandomDropEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"The random drop table contains entries describing a
process that drops packets randomly. Entries in this
table is intended to be pointed to by dsAlgDropSpecific
when dsAlgDropType is randomDrop(4)."

REFERENCE

"An Informal Management Model for Diffserv Routers,
RFC 3290, section 7.1.3"

::= { dsPolicyClasses 10 }

RandomDropEntry OBJECT-TYPE

SYNTAX DsRandomDropEntry

STATUS current

DESCRIPTION

"An entry describes a process that drops packets
according to a random algorithm."

PIB-INDEX { dsRandomDropPrid }

UNIQUENESS { dsRandomDropMinThreshBytes,
 dsRandomDropMinThreshPkts,
 dsRandomDropMaxThreshBytes,
 dsRandomDropMaxThreshPkts,

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```

        dsRandomDropProbMax,
        dsRandomDropWeight,
        dsRandomDropSamplingRate
    }

```

```

::= { dsRandomDropTable 1 }

```

```

RandomDropEntry ::= SEQUENCE {
    dsRandomDropPrid          InstanceId,
    dsRandomDropMinThreshBytes Unsigned32,
    dsRandomDropMinThreshPkts Unsigned32,
    dsRandomDropMaxThreshBytes Unsigned32,
    dsRandomDropMaxThreshPkts Unsigned32,
    dsRandomDropProbMax      Unsigned32,
    dsRandomDropWeight       Unsigned32,
    dsRandomDropSamplingRate Unsigned32
}

```

RandomDropPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an instance of the class."

```

::= { dsRandomDropEntry 1 }

```

RandomDropMinThreshBytes OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

UNITS "bytes"

STATUS current

DESCRIPTION

"The average queue depth in bytes, beyond which traffic has a non-zero probability of being dropped."

```

::= { dsRandomDropEntry 2 }

```

RandomDropMinThreshPkts OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

UNITS "packets"

STATUS current

DESCRIPTION

"The average queue depth in packets, beyond which traffic has a non-zero probability of being dropped."

```

::= { dsRandomDropEntry 3 }

```

RandomDropMaxThreshBytes OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

UNITS "bytes"

STATUS current

DESCRIPTION

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"The average queue depth beyond which traffic has a probability indicated by dsRandomDropProbMax of being dropped or marked. Note that this differs from the physical queue limit, which is stored in dsAlgDropQThreshold."

::= { dsRandomDropEntry 4 }

RandomDropMaxThreshPkts OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

UNITS "packets"

STATUS current

DESCRIPTION

"The average queue depth beyond which traffic has a probability indicated by dsRandomDropProbMax of being dropped or marked. Note that this differs from the physical queue limit, which is stored in dsAlgDropQThreshold."

::= { dsRandomDropEntry 5 }

RandomDropProbMax OBJECT-TYPE

SYNTAX Unsigned32 (0..1000)

STATUS current

DESCRIPTION

"The worst case random drop probability, expressed in drops per thousand packets.

For example, if every packet may be dropped in the worst case (100%), this has the value 1000. Alternatively, if in the worst case one percent (1%) of traffic may be dropped, it has the value 10."

::= { dsRandomDropEntry 6 }

RandomDropWeight OBJECT-TYPE

SYNTAX Unsigned32 (0..4294967295)

STATUS current

DESCRIPTION

"The weighting of past history in affecting the Exponentially Weighted Moving Average function which calculates the current average queue depth. The equation uses dsRandomDropWeight/MaxValue as the coefficient for the new sample in the equation, and (MaxValue - dsRandomDropWeight)/MaxValue as the coefficient of the old value, where, MaxValue is determined via capability reported by the PEP.

Implementations may further limit the values of dsRandomDropWeight via the capability tables."

::= { dsRandomDropEntry 7 }

RandomDropSamplingRate OBJECT-TYPE

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SYNTAX Unsigned32 (0..1000000)

STATUS current

DESCRIPTION

"The number of times per second the queue is sampled for queue average calculation. A value of zero means the queue is sampled approximately each time a packet is enqueued (or dequeued)."

::= { dsRandomDropEntry 8 }

Queue Table

An entry of dsQTable represents a FIFO queue diffserv functional data path element as described in [MODEL] section 7.1.1.

Notice the specification of scheduling parameters for a queue as part of the input to a scheduler functional data path element as described in [MODEL] section 7.1.2. This allows building of hierarchical queuing/scheduling.

A queue therefore is parameterized by:

1. Which scheduler will service this queue, dsQNext.
2. How the scheduler will service this queue, with respect to all the other queues the same scheduler needs to service, dsQMinRate and dsQMaxRate.

Notice one or more upstream diffserv functional data path element may share, point to, a dsQTable entry as described in [MODEL] section 7.1.1.

QTable OBJECT-TYPE

```
SYNTAX          SEQUENCE OF DsQEntry
PIB-ACCESS      install
STATUS          current
DESCRIPTION
"The Queue Table enumerates the queues."
::= { dsPolicyClasses 11 }
```

QEntry OBJECT-TYPE

```
SYNTAX          DsQEntry
STATUS          current
DESCRIPTION
    "An entry in the Queue Table describes a single queue
    as a functional data path element."
PIB-INDEX { dsQPrid }
UNIQUENESS { dsQNext,
```

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```
        dsQMinRate,
        dsQMaxRate }
::= { dsQTable 1 }
```

```
QEntry ::= SEQUENCE {
    dsQPrid          InstanceId,
    dsQNext          Prid,
    dsQMinRate       Prid,
    dsQMaxRate       Prid
}
```

QPrid OBJECT-TYPE

```
SYNTAX          InstanceId
STATUS          current
DESCRIPTION
    "An arbitrary integer index that uniquely identifies an
    instance of the class."
::= { dsQEntry 1 }
```


QNext OBJECT-TYPE

SYNTAX Prid
STATUS current

DESCRIPTION

"This selects the next diffserv scheduler. This must point to a dsSchedulerEntry.

A value of zeroDotZero in this attribute indicates an incomplete dsQEntry instance. In such a case, the entry has no operational effect, since it has no parameters to give it meaning."

::= { dsQEntry 2 }

QMinRate OBJECT-TYPE

SYNTAX Prid
STATUS current

DESCRIPTION

"This Prid indicates the entry in dsMinRateTable the scheduler, pointed to by dsQNext, should use to service this queue.

If this value is zeroDotZero then minimum rate and priority is unspecified.

If this value is not zeroDotZero then the instance pointed to must exist prior to installing this entry."

::= { dsQEntry 3 }

QMaxRate OBJECT-TYPE

SYNTAX Prid
STATUS current

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DESCRIPTION

"This Prid indicates the entry in dsMaxRateTable the scheduler, pointed to by dsQNext, should use to service this queue.

If this value is zeroDotZero, then the maximum rate is the line speed of the interface.

If this value is not zeroDotZero, then the instance pointed to must exist prior to installing this entry."

::= { dsQEntry 4 }

Scheduler Table

The Scheduler Table is used for representing packet schedulers: it provides flexibility for multiple scheduling algorithms, each servicing multiple queues, to be used on the same logical/physical interface of a data path.

Notice the servicing parameters the scheduler uses is specified by each of its upstream functional data path elements, queues or schedulers of this PIB.

The coordination and coherency between the servicing parameters of the scheduler's upstream functional data path elements must be maintained for the scheduler to function correctly.

The dsSchedulerMinRate and dsSchedulerMaxRate attributes are used for specifying the servicing parameters for output of a scheduler when its downstream functional data path element is another scheduler. This is used for building hierarchical queue/scheduler.

More discussion of the scheduler functional data path element is in [MODEL] section 7.1.2.

SchedulerTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsSchedulerEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"The Scheduler Table enumerates packet schedulers. Multiple scheduling algorithms can be used on a given datapath, with each algorithm described by one dsSchedulerEntry."

REFERENCE

"An Informal Management Model for Diffserv Routers, RFC 3290, section 7.1.2"

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```
::= { dsPolicyClasses 12 }
```

SchedulerEntry OBJECT-TYPE

SYNTAX DsSchedulerEntry

STATUS current

DESCRIPTION

"An entry in the Scheduler Table describing a single instance of a scheduling algorithm."

PIB-INDEX { dsSchedulerPrid }

UNIQUENESS { dsSchedulerNext,
dsSchedulerMethod,
dsSchedulerMinRate,
dsSchedulerMaxRate }

```
::= { dsSchedulerTable 1 }
```

SchedulerEntry ::= SEQUENCE {

dsSchedulerPrid	InstanceId,
dsSchedulerNext	Prid,
dsSchedulerMethod	AutonomousType,
dsSchedulerMinRate	Prid,
dsSchedulerMaxRate	Prid

SchedulerPrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an instance of the class."

```
::= { dsSchedulerEntry 1 }
```

SchedulerNext OBJECT-TYPE

SYNTAX Prid
 STATUS current
 DESCRIPTION

"This selects the next diffserv functional datapath element to handle traffic for this data path.

This attribute normally have a value of zeroDotZero to indicate no further DiffServ treatment is performed on traffic of this datapath. The use of zeroDotZero is the normal usage for the last functional datapath element. Any value other than zeroDotZero must point to a valid (pre-existing) instance of one of:

dsSchedulerEntry
 dsQEntry,

or:

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dsClfrEntry
 dsMeterEntry
 dsActionEntry
 dsAlgDropEntry

This points to another dsSchedulerEntry for implementation of multiple scheduler methods for the same data path, and for implementation of hierarchical schedulers."

DEFVAL { zeroDotZero }
 ::= { dsSchedulerEntry 2 }

SchedulerMethod OBJECT-TYPE

SYNTAX AutonomousType
 STATUS current
 DESCRIPTION

"The scheduling algorithm used by this Scheduler.

Standard values for generic algorithms:

diffServSchedulerPriority,
 diffServSchedulerWRR,
 diffServSchedulerWFQ

are specified in the DiffServ MIB.

Additional values may be further specified in other PIBs.

A value of zeroDotZero indicates this is unknown."

REFERENCE

"An Informal Management Model for Diffserv Routers,
 RFC 3290, section 7.1.2"

::= { dsSchedulerEntry 3 }

SchedulerMinRate OBJECT-TYPE

SYNTAX Prid
 STATUS current
 DESCRIPTION

"This Prid indicates the entry in dsMinRateTable which indicates the priority or minimum output rate from this scheduler. This attribute is used only when there is more than one level of scheduler.

When it has the value zeroDotZero, it indicates that no

Minimum rate or priority is imposed."

DEFVAL { zeroDotZero }

::= { dsSchedulerEntry 4 }

SchedulerMaxRate OBJECT-TYPE

SYNTAX Prid

STATUS current

DESCRIPTION

"This Prid indicates the entry in dsMaxRateTable

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which indicates the maximum output rate from this scheduler. When more than one maximum rate applies (e.g., a multi-rate shaper is used), it points to the first of the rate entries. This attribute is only used when there is more than one level of scheduler.

When it has the value zeroDotZero, it indicates that no Maximum rate is imposed."

DEFVAL { zeroDotZero }

::= { dsSchedulerEntry 5 }

Minimum Rate Parameters Table

The parameters used by a scheduler for its inputs or outputs are maintained separately from the Queue or Scheduler table entries for reusability reasons and so that they may be used by both queues and schedulers. This follows the approach for separation of data path elements from parameterization that is used throughout this PIB.

Use of these Minimum Rate Parameter Table entries by Queues and Schedulers allows the modeling of hierarchical scheduling systems.

Specifically, a Scheduler has one or more inputs and one output. Any queue feeding a scheduler, or any scheduler which feeds a second scheduler, might specify a minimum transfer rate by pointing to a Minimum Rate Parameter Table entry.

The dsMinRatePriority/Absolute/Relative attributes are used as parameters to the work-conserving portion of a scheduler: "work-conserving" implies that the scheduler can continue to emit data as long as there is data available at its input(s). This has the effect of guaranteeing a certain priority relative to other scheduler inputs and/or a certain minimum proportion of the available output bandwidth. Properly configured, this means a certain minimum rate, which may be exceeded should traffic be available should there be spare bandwidth after all other classes have had opportunities to consume their own minimum rates.

MinRateTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsMinRateEntry

PIB-ACCESS install

STATUS current

DESCRIPTION

"The Minimum Rate Table enumerates individual
sets of scheduling parameter that can be used/reused

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by Queues and Schedulers."
::= { dsPolicyClasses 13 }

MinRateEntry OBJECT-TYPE

SYNTAX DsMinRateEntry

STATUS current

DESCRIPTION

"An entry in the Minimum Rate Table describes
a single set of scheduling parameter for use by
queues and schedulers."

PIB-INDEX { dsMinRatePrid }

UNIQUENESS { dsMinRatePriority,
dsMinRateAbsolute,
dsMinRateRelative }

::= { dsMinRateTable 1 }

MinRateEntry ::= SEQUENCE {

dsMinRatePrid InstanceId,

dsMinRatePriority Unsigned32,

dsMinRateAbsolute Unsigned32,

dsMinRateRelative Unsigned32

MinRatePrid OBJECT-TYPE

SYNTAX InstanceId

STATUS current

DESCRIPTION

"An arbitrary integer index that uniquely identifies an
instance of the class."

::= { dsMinRateEntry 1 }

MinRatePriority OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

STATUS current

DESCRIPTION

"The priority of this input to the associated scheduler,
relative to the scheduler's other inputs. Higher Priority
value indicates the associated queue/scheduler will get
service first before others with lower Priority values."

::= { dsMinRateEntry 2 }

MinRateAbsolute OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

UNITS "kilobits per second"

STATUS current

DESCRIPTION

"The minimum absolute rate, in kilobits/sec, that a downstream
scheduler element should allocate to this queue. If the value

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is zero, then there is effectively no minimum rate guarantee. If the value is non-zero, the scheduler will assure the servicing of this queue to at least this rate.

Note that this attribute's value is coupled to that of dsMinRateRelative: changes to one will affect the value of the other.

[IFMIB] defines ifSpeed as Gauge32 in units of bits per second, and ifHighSpeed as Gauge32 in units of 1,000,000 bits per second.

This yields the following equations:

$$\text{RateRelative} = [(\text{RateAbsolute} * 1000) / \text{ifSpeed}] * 1,000$$

Where, 1000 is for converting kbps used by RateAbsolute to bps used by ifSpeed, 1,000 is for 'in units of 1/1,000 of 1' for RateRelative.

or, if appropriate:

$$\text{RateRelative} = \{ [(\text{RateAbsolute} * 1000) / 1,000,000] / \text{ifHighSpeed} \} * 1,000$$

Where, 1000 and 1,000,000 is for converting kbps used by RateAbsolute to 1 million bps used by ifHighSpeed, 1,000 is for 'in units of 1/1,000 of 1' for RateRelative."

REFERENCE

"ifSpeed, ifHighSpeed from the IF-MIB, RFC 2863."
::= { dsMinRateEntry 3 }

MinRateRelative OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

STATUS current

DESCRIPTION

"The minimum rate that a downstream scheduler element should allocate to this queue, relative to the maximum rate of the interface as reported by ifSpeed or ifHighSpeed, in units of 1/1,000 of 1. If the value is zero, then there is effectively no minimum rate guarantee. If the value is non-zero, the scheduler will assure the servicing of this queue to at least this rate.

Note that this attribute's value is coupled to that of dsMinRateAbsolute: changes to one will affect the value of the other.

[IFMIB] defines ifSpeed as Gauge32 in units of bits per second, and ifHighSpeed as Gauge32 in units of 1,000,000 bits per second.

• This yields the following equations:

$$\text{RateRelative} = [(\text{RateAbsolute} * 1000) / \text{ifSpeed}] * 1,000$$

Where, 1000 is for converting kbps used by RateAbsolute to bps used by ifSpeed, 1,000 is for 'in units of 1/1,000 of 1' for RateRelative.

or, if appropriate:

$$\text{RateRelative} = \frac{[(\text{RateAbsolute} * 1000) / 1,000,000]}{\text{ifHighSpeed}} * 1,000$$

Where, 1000 and 1,000,000 is for converting kbps used by RateAbsolute to 1 million bps used by ifHighSpeed, 1,000 is for 'in units of 1/1,000 of 1' for RateRelative."

REFERENCE

"ifSpeed, ifHighSpeed from the IF-MIB, RFC 2863."
::= { dsMinRateEntry 4 }

Maximum Rate Parameters Table

The parameters used by a scheduler for its inputs or outputs are maintained separately from the Queue or Scheduler table entries for reusability reasons and so that they may be used by both queues and schedulers. This follows the approach for separation of data path elements from parameterization that is used throughout this PIB.

Use of these Maximum Rate Parameter Table entries by Queues and Schedulers allows the modeling of hierarchical scheduling systems.

Specifically, a Scheduler has one or more inputs and one output. Any queue feeding a scheduler, or any scheduler which feeds a second scheduler, might specify a maximum transfer rate by pointing to a Maximum Rate Parameter Table entry. Multi-rate shapers, such as a Dual Leaky Bucket algorithm, specify their rates using multiple Maximum Rate Parameter Entries with the same dsMaxRateId but different dsMaxRateLevels.

The dsMaxRateLevel/Absolute/Relative attributes are used as

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parameters to the non-work-conserving portion of a scheduler: non-work-conserving implies that the scheduler may sometimes not emit a packet, even if there is data available at its input(s). This has the effect of limiting the servicing of the queue/scheduler input or output, in effect performing shaping of the packet stream passing through the queue/scheduler, as described in the Informal Differentiated Services Model section 7.2.

MaxRateTable OBJECT-TYPE

SYNTAX SEQUENCE OF DsMaxRateEntry
 PIB-ACCESS install
 STATUS current
 DESCRIPTION
 "The Maximum Rate Table enumerates individual
 sets of scheduling parameter that can be used/reused
 by Queues and Schedulers."
 ::= { dsPolicyClasses 14 }

MaxRateEntry OBJECT-TYPE

SYNTAX DsMaxRateEntry
 STATUS current
 DESCRIPTION
 "An entry in the Maximum Rate Table describes
 a single set of scheduling parameter for use by
 queues and schedulers."
 PIB-INDEX { dsMaxRatePrid }
 UNIQUENESS { dsMaxRateId,
 dsMaxRateLevel,
 dsMaxRateAbsolute,
 dsMaxRateRelative,
 dsMaxRateThreshold }
 ::= { dsMaxRateTable 1 }

MaxRateEntry ::= SEQUENCE {
 dsMaxRatePrid InstanceId,
 dsMaxRateId Unsigned32,
 dsMaxRateLevel Unsigned32,
 dsMaxRateAbsolute Unsigned32,
 dsMaxRateRelative Unsigned32,
 dsMaxRateThreshold BurstSize

MaxRatePrid OBJECT-TYPE

SYNTAX InstanceId
 STATUS current
 DESCRIPTION

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"An arbitrary integer index that uniquely identifies an
 instance of the class."
 ::= { dsMaxRateEntry 1 }

MaxRateId OBJECT-TYPE

SYNTAX Unsigned32 (0..4294967295)
 STATUS current
 DESCRIPTION
 "An identifier used together with dsMaxRateLevel for
 representing a multi-rate shaper. This attribute is used for
 associating all the rate attributes of a multi-rate shaper.
 Each dsMaxRateEntry of a multi-rate shaper must have the same
 value in this attribute. The different rates of a multi-rate
 shaper is identified using dsMaxRateLevel.
 This attribute uses the value of zero to indicate this
 attribute is not used, for single rate shaper."
 DEFVAL { 0 }
 ::= { dsMaxRateEntry 2 }

MaxRateLevel OBJECT-TYPE

SYNTAX Unsigned32 (1..32)

STATUS current

DESCRIPTION

"An index that indicates which level of a multi-rate shaper is being given its parameters. A multi-rate shaper has some number of rate levels. Frame Relay's dual rate specification refers to a 'committed' and an 'excess' rate; ATM's dual rate specification refers to a 'mean' and a 'peak' rate. This table is generalized to support an arbitrary number of rates. The committed or mean rate is level 1, the peak rate (if any) is the highest level rate configured, and if there are other rates they are distributed in monotonically increasing order between them.

When the entry is used for a single rate shaper, this attribute contains a value of one."

DEFVAL { 1 }

::= { dsMaxRateEntry 3 }

MaxRateAbsolute OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

UNITS "kilobits per second"

STATUS current

DESCRIPTION

"The maximum rate in kilobits/sec that a downstream scheduler element should allocate to this queue. If the value is zero, then there is effectively no maximum rate limit and that the scheduler should attempt to be work-conserving for this queue. If the value

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is non-zero, the scheduler will limit the servicing of this queue to, at most, this rate in a non-work-conserving manner.

Note that this attribute's value is coupled to that of dsMaxRateRelative: changes to one will affect the value of the other.

[IFMIB] defines ifSpeed as Gauge32 in units of bits per second, and ifHighSpeed as Gauge32 in units of 1,000,000 bits per second.

This yields the following equations:

$$\text{RateRelative} = [(\text{RateAbsolute} * 1000) / \text{ifSpeed}] * 1,000$$

Where, 1000 is for converting kbps used by RateAbsolute to bps used by ifSpeed, 1,000 is for 'in units of 1/1,000 of 1' for RateRelative.

or, if appropriate:

$$\begin{aligned} \text{RateRelative} = \\ \{ [(\text{RateAbsolute} * 1000) / 1,000,000] / \text{ifHighSpeed} \} * \\ 1,000 \end{aligned}$$

Where, 1000 and 1,000,000 is for converting kbps used by RateAbsolute to 1 million bps used by ifHighSpeed, 1,000 is for 'in units of 1/1,000 of 1' for RateRelative."
 ::= { dsMaxRateEntry 4 }

MaxRateRelative OBJECT-TYPE

SYNTAX Unsigned32 (1..4294967295)

STATUS current

DESCRIPTION

"The maximum rate that a downstream scheduler element should allocate to this queue, relative to the maximum rate of the interface as reported by ifSpeed or ifHighSpeed, in units of 1/1,000 of 1. If the value is zero, then there is effectively no maximum rate limit and the scheduler should attempt to be work-conserving for this queue. If the value is non-zero, the scheduler will limit the servicing of this queue to, at most, this rate in a non-work-conserving manner.

Note that this attribute's value is coupled to that of dsMaxRateAbsolute: changes to one will affect the value of the other.

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[IFMIB] defines ifSpeed as Gauge32 in units of bits per second, and ifHighSpeed as Gauge32 in units of 1,000,000 bits per second.

This yields the following equations:

$$\text{RateRelative} = [(\text{RateAbsolute} * 1000) / \text{ifSpeed}] * 1,000$$

Where, 1000 is for converting kbps used by RateAbsolute to bps used by ifSpeed, 1,000 is for 'in units of 1/1,000 of 1' for RateRelative.

or, if appropriate:

$$\text{RateRelative} = \{ [(\text{RateAbsolute} * 1000) / 1,000,000] / \text{ifHighSpeed} \} * 1,000$$

Where, 1000 and 1,000,000 is for converting kbps used by RateAbsolute to 1 million bps used by ifHighSpeed, 1,000 is for 'in units of 1/1,000 of 1' for RateRelative."

REFERENCE

"ifSpeed, ifHighSpeed from the IF-MIB, RFC 2863."
 ::= { dsMaxRateEntry 5 }

MaxRateThreshold OBJECT-TYPE

SYNTAX BurstSize

UNITS "Bytes"

STATUS current

DESCRIPTION

"The number of bytes of queue depth at which the rate of a multi-rate scheduler will increase to the next output rate. In

the last PRI for such a shaper, this threshold is ignored and by convention is zero."

REFERENCE

"Adaptive Rate Shaper, RFC 2963"

:= { dsMaxRateEntry 6 }

Conformance Section

PolicyPibCompliances

OBJECT IDENTIFIER ::= { dsPolicyPibConformance 1 }

PolicyPibGroups

OBJECT IDENTIFIER ::= { dsPolicyPibConformance 2 }

PolicyPibCompliance MODULE-COMPLIANCE

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STATUS current

DESCRIPTION

"Describes the requirements for conformance to the QoS Policy PIB."

MODULE FRAMEWORK-PIB

MANDATORY-GROUPS {

frwkPrcSupportGroup,
frwkPibIncarnationGroup,
frwkDeviceIdGroup,
frwkCompLimitsGroup,
frwkCapabilitySetGroup,
frwkRoleComboGroup,
frwkIfRoleComboGroup,
frwkBaseFilterGroup,
frwkIpFilterGroup }

OBJECT frwkPibIncarnationLongevity

PIB-MIN-ACCESS notify

DESCRIPTION

"Install support is required if policy expiration is to be supported."

OBJECT frwkPibIncarnationTtl

PIB-MIN-ACCESS notify

DESCRIPTION

"Install support is required if policy expiration is to be supported."

MODULE DIFFSERV-PIB -- this module

MANDATORY-GROUPS {

dsPibBaseIfCapsGroup,
dsPibIfClassificationCapsGroup,
dsPibIfAlgDropCapsGroup,
dsPibIfQueueCapsGroup,
dsPibIfSchedulerCapsGroup,
dsPibIfMaxRateCapsGroup,
dsPibIfElmDepthCapsGroup,
dsPibIfElmLinkCapsGroup,

```

dsPibDataPathGroup,
dsPibClfrGroup,
dsPibClfrElementGroup,
dsPibActionGroup,
dsPibAlgDropGroup,
dsPibQGroup,
dsPibSchedulerGroup,
dsPibMinRateGroup,
dsPibMaxRateGroup }

```

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GROUP dsPibIfMeteringCapsGroup

DESCRIPTION

"This group is mandatory for devices that implement metering functions."

GROUP dsPibMeterGroup

DESCRIPTION

"This group is mandatory for devices that implement metering functions."

GROUP dsPibTBParamGroup

DESCRIPTION

"This group is mandatory for devices that implement token-bucket metering functions."

GROUP dsPibDscpMarkActGroup

DESCRIPTION

"This group is mandatory for devices that implement DSCP-Marking functions."

GROUP dsPibMQAlgDropGroup

DESCRIPTION

"This group is mandatory for devices that implement Multiple Queue Measured Algorithmic Drop functions."

GROUP dsPibRandomDropGroup

DESCRIPTION

"This group is mandatory for devices that implement Random Drop functions."

OBJECT dsClfrId

PIB-MIN-ACCESS not-accessible

DESCRIPTION

"Install support is not required."

OBJECT dsClfrElementClfrId

PIB-MIN-ACCESS not-accessible

DESCRIPTION

"Install support is not required."

OBJECT dsClfrElementPrecedence

PIB-MIN-ACCESS not-accessible

DESCRIPTION

"Install support is not required."

* OBJECT dsClfrElementNext
PIB-MIN-ACCESS not-accessible

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DESCRIPTION

"Install support is not required."

OBJECT dsClfrElementSpecific
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsMeterSucceedNext
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsMeterFailNext
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsMeterSpecific
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsTBParamType
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsTBParamRate
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsTBParamBurstSize
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsTBParamInterval
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsActionNext
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

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OBJECT dsActionSpecific
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsAlgDropType
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsAlgDropNext
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsAlgDropQMeasure
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsAlgDropQThreshold
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsAlgDropSpecific
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsRandomDropMinThreshBytes
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsRandomDropMinThreshPkts
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsRandomDropMaxThreshBytes
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsRandomDropMaxThreshPkts
PIB-MIN-ACCESS not-accessible
DESCRIPTION

"Install support is not required."

OBJECT dsRandomDropProbMax
PIB-MIN-ACCESS not-accessible

DESCRIPTION
"Install support is not required."

OBJECT dsRandomDropWeight
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsRandomDropSamplingRate
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsQNext
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsQMinRate
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsQMaxRate
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsSchedulerNext
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsSchedulerMethod
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsSchedulerMinRate
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsSchedulerMaxRate

PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsMinRatePriority
PIB-MIN-ACCESS not-accessible
DESCRIPTION
"Install support is not required."

OBJECT dsMinRateAbsolute
PIB-MIN-ACCESS not-accessible

```

DESCRIPTION
    "Install support is not required."

OBJECT dsMinRateRelative
PIB-MIN-ACCESS not-accessible
DESCRIPTION
    "Install support is not required."

OBJECT dsMaxRateId
PIB-MIN-ACCESS not-accessible
DESCRIPTION
    "Install support is not required."

OBJECT dsMaxRateLevel
PIB-MIN-ACCESS not-accessible
DESCRIPTION
    "Install support is not required."

OBJECT dsMaxRateAbsolute
PIB-MIN-ACCESS not-accessible
DESCRIPTION
    "Install support is not required."

OBJECT dsMaxRateRelative
PIB-MIN-ACCESS not-accessible
DESCRIPTION
    "Install support is not required."

OBJECT dsMaxRateThreshold
PIB-MIN-ACCESS not-accessible
DESCRIPTION
    "Install support is not required."

::= { dsPolicyPibCompliances 1 }

```

```

PibBaseIfCapsGroup OBJECT-GROUP
OBJECTS {

```

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```

    dsBaseIfCapsPrid, dsBaseIfCapsDirection
}
STATUS current
DESCRIPTION
    "The Base Interface Capability Group defines the PIB
    Objects that describe the base for interface capabilities."
::= { dsPolicyPibGroups 1 }

PibIfClassificationCapsGroup OBJECT-GROUP
OBJECTS {
    dsIfClassificationCapsSpec
}
STATUS current
DESCRIPTION
    "The Classification Capability Group defines the PIB
    Objects that describe the classification capabilities."
::= { dsPolicyPibGroups 2 }

```



```
PibIfMeteringCapsGroup OBJECT-GROUP
OBJECTS {
    dsIfMeteringCapsSpec
}
STATUS current
DESCRIPTION
    "The Metering Capability Group defines the PIB
    Objects that describe the metering capabilities."
 ::= { dsPolicyPibGroups 3 }

PibIfAlgDropCapsGroup OBJECT-GROUP
OBJECTS {
    dsIfAlgDropCapsType, dsIfAlgDropCapsMQCount
}
STATUS current
DESCRIPTION
    "The Algorithmic Dropper Capability Group defines the
    PIB Objects that describe the algorithmic dropper
    capabilities."
 ::= { dsPolicyPibGroups 4 }

PibIfQueueCapsGroup OBJECT-GROUP
OBJECTS {
    dsIfQueueCapsMinQueueSize, dsIfQueueCapsMaxQueueSize,
    dsIfQueueCapsTotalQueueSize
}
STATUS current
DESCRIPTION
    "The Queueing Capability Group defines the PIB
    Objects that describe the queueing capabilities."
```

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```
 ::= { dsPolicyPibGroups 5 }
```

```
PibIfSchedulerCapsGroup OBJECT-GROUP
    OBJECTS {
        dsIfSchedulerCapsServiceDisc, dsIfSchedulerCapsMaxInputs,
        dsIfSchedulerCapsMinMaxRate
    }
    STATUS current
    DESCRIPTION
        "The Scheduler Capability Group defines the PIB
        Objects that describe the scheduler capabilities."
    ::= { dsPolicyPibGroups 6 }
```

```
PibIfMaxRateCapsGroup OBJECT-GROUP
OBJECTS {
    dsIfMaxRateCapsMaxLevels
}
STATUS current
DESCRIPTION
    "The Max Rate Capability Group defines the PIB
    Objects that describe the max rate capabilities."
 ::= { dsPolicyPibGroups 7 }
```

```
PibIfElmDepthCapsGroup OBJECT-GROUP
OBJECTS {
```

```

    dsIfElmDepthCapsPrc, dsIfElmDepthCapsCascadeMax
}
STATUS current
DESCRIPTION
    "The DataPath Element Depth Capability Group defines the PIB
    Objects that describe the datapath element depth
    capabilities."
::= { dsPolicyPibGroups 8 }

```

PibIfElmLinkCapsGroup OBJECT-GROUP

```

OBJECTS {
    dsIfElmLinkCapsPrc, dsIfElmLinkCapsAttr,
    dsIfElmLinkCapsNextPrc
}
STATUS current
DESCRIPTION
    "The DataPath Element Linkage Capability Group defines the
    PIB Objects that describe the datapath element linkage
    capabilities."
::= { dsPolicyPibGroups 9 }

```

PibDataPathGroup OBJECT-GROUP

```

OBJECTS {

```

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```

    dsDataPathPrid, dsDataPathCapSetName,
    dsDataPathRoles, dsDataPathIfDirection,
    dsDataPathStart

```

```

}
STATUS current
DESCRIPTION
    "The Data Path Group defines the PIB Objects that
    describe a data path."
::= { dsPolicyPibGroups 10 }

```

PibClfrGroup OBJECT-GROUP

```

OBJECTS {
    dsClfrPrid, dsClfrId
}
STATUS current
DESCRIPTION
    "The Classifier Group defines the PIB Objects that
    describe a generic classifier."
::= { dsPolicyPibGroups 11 }

```

PibClfrElementGroup OBJECT-GROUP

```

OBJECTS {
    dsClfrElementPrid, dsClfrElementClfrId,
    dsClfrElementPrecedence, dsClfrElementNext,
    dsClfrElementSpecific
}
STATUS current
DESCRIPTION
    "The Classifier Group defines the PIB Objects that
    describe a generic classifier."
::= { dsPolicyPibGroups 12 }

```

PibMeterGroup OBJECT-GROUP

```
OBJECTS {
    dsMeterPrid, dsMeterSucceedNext,
    dsMeterFailNext, dsMeterSpecific
}
STATUS current
DESCRIPTION
    "The Meter Group defines the objects used in describing a generic meter element."
::= { dsPolicyPibGroups 13 }
```

PibTBParamGroup OBJECT-GROUP

```
OBJECTS {
    dsTBParamPrid, dsTBParamType, dsTBParamRate,
    dsTBParamBurstSize, dsTBParamInterval
}
```

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```
STATUS current
DESCRIPTION
    "The Token-Bucket Parameter Group defines the objects used in describing a single-rate token bucket meter element."
::= { dsPolicyPibGroups 14 }
```

PibActionGroup OBJECT-GROUP

```
OBJECTS {
    dsActionPrid, dsActionNext, dsActionSpecific
}
STATUS current
DESCRIPTION
    "The Action Group defines the objects used in describing a generic action element."
::= { dsPolicyPibGroups 15 }
```

PibDscpMarkActGroup OBJECT-GROUP

```
OBJECTS {
    dsDscpMarkActPrid, dsDscpMarkActDscp
}
STATUS current
DESCRIPTION
    "The DSCP Mark Action Group defines the objects used in describing a DSCP Marking Action element."
::= { dsPolicyPibGroups 16 }
```

PibAlgDropGroup OBJECT-GROUP

```
OBJECTS {
    dsAlgDropPrid, dsAlgDropType, dsAlgDropNext,
    dsAlgDropQMeasure, dsAlgDropQThreshold,
    dsAlgDropSpecific
}
STATUS current
DESCRIPTION
    "The Algorithmic Drop Group contains the objects that describe algorithmic dropper operation and configuration."
::= { dsPolicyPibGroups 17 }
```

PibMQAlgDropGroup OBJECT-GROUP

OBJECTS {

dsMQAlgDropExceedNext

}

STATUS current

DESCRIPTION

"The Multiple Queue Measured Algorithmic Drop Group
contains the objects that describe multiple queue

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measured algorithmic dropper operation and configuration."
::= { dsPolicyPibGroups 18 }

PibRandomDropGroup OBJECT-GROUP

OBJECTS {

dsRandomDropPrid,

dsRandomDropMinThreshBytes,

dsRandomDropMinThreshPkts,

dsRandomDropMaxThreshBytes,

dsRandomDropMaxThreshPkts,

dsRandomDropProbMax,

dsRandomDropWeight,

dsRandomDropSamplingRate

}

STATUS current

DESCRIPTION

"The Random Drop Group augments the Algorithmic Drop Group
for random dropper operation and configuration."

::= { dsPolicyPibGroups 19 }

PibQGroup OBJECT-GROUP

OBJECTS {

dsQPrid, dsQNext, dsQMinRate, dsQMaxRate

}

STATUS current

DESCRIPTION

"The Queue Group contains the objects that describe
an interface type's queues."

::= { dsPolicyPibGroups 20 }

PibSchedulerGroup OBJECT-GROUP

OBJECTS {

dsSchedulerPrid, dsSchedulerNext, dsSchedulerMethod,

dsSchedulerMinRate, dsSchedulerMaxRate

}

STATUS current

DESCRIPTION

"The Scheduler Group contains the objects that
describe packet schedulers on interface types."

::= { dsPolicyPibGroups 21 }

PibMinRateGroup OBJECT-GROUP

OBJECTS {

dsMinRatePrid, dsMinRatePriority,

dsMinRateAbsolute, dsMinRateRelative

}

"The Minimum Rate Group contains the objects
that describe packet schedulers' parameters on interface
types."

::= { dsPolicyPibGroups 22 }

PibMaxRateGroup OBJECT-GROUP

OBJECTS {
 dsMaxRatePrid, dsMaxRateId, dsMaxRateLevel,
 dsMaxRateAbsolute, dsMaxRateRelative,
 dsMaxRateThreshold
}

STATUS current

DESCRIPTION

"The Maximum Rate Group contains the objects
that describe packet schedulers' parameters on interface
types."

::= { dsPolicyPibGroups 23 }

D

Acknowledgments

Early versions of this specification were also co-authored by Michael Fine, John Seligson, Carol Bell, Andrew Smith, and Francis Reichmeyer.

This PIB builds on all the work that has gone into the Informal Management Model for DiffServ Routers and Management Information Base for the Differentiated Services Architecture.

It has been developed with the active involvement of many people, but most notably Diana Rawlins, Martin Bokaemper, Walter Weiss, and Bert Wijnen.

. Security Considerations

The information contained in a PIB when transported by the COPS protocol [COPS-PR] may be sensitive, and its function of provisioning a PEP requires that only authorized communication take place.

In this PIB, there are no PRCs which are sensitive in their own right, such as passwords or monetary amounts. But there are a number of PRCs in this PIB that may contain information that may be sensitive from a business perspective, in that they may represent a customer's service contract or the filters that the service provider chooses to apply to a customer's traffic. These PRCs have a PIB-ACCESS clause of install:

dsDataPathTable, dsClfrTable, dsClfrElementTable, dsMeterTable,
dsTBParamTable, dsActionTable, dsDscpMarkActTable, dsAlgDropTable,
dsMQAlgDropTable, dsRandomDropTable, dsQTable, dsSchedulerTable,
dsMinRateTable, dsMaxRateTable

Malicious altering of the above PRCs may affect the DiffServ behavior of the device being provisioned.

Malicious access of the above PRCs exposes policy information concerning how the device is provisioned.

This PIB also contain PRCs with PIB-ACCESS clause of notify:

dsBaseIfCapTable, dsIfClassificationCapTable,
dsIfMeteringCapTable, dsIfAlgDropCapTable, dsIfQueueCapTable,
dsIfSchedulerCapTable, dsIfMaxRateCapTable, dsIfElmDepthCapTable,
dsIfElmLinkCapTable

Malicious access of the above PRCs exposes information concerning the device being provisioned.

The use of IPSEC between PDP and PEP, as described in [COPS], provides the necessary protection.

. Intellectual Property Considerations

The IETF has been notified of intellectual property rights claimed in regard to some or all of the specification contained in this document. For more information consult the online list of claimed rights.

. IANA Considerations

This document describes the dsPolicyPib Policy Information Base (PIB) modules for standardization under the "pib" branch registered with IANA. The IANA has assigned a PIB number (4) under the "pib" branch.

[SPPI] PIB SUBJECT-CATEGORIES are mapped to COPS Client Types. IANA Considerations for SUBJECT-CATEGORIES follow the same requirements as specified in [COPS] IANA Considerations for COPS Client Types. The DiffServ QoS PIB defines a new COPS Client Type in the Standards space. The IANA has assigned a COPS client type diffServ (2) as described in [COPS] IANA Considerations. IANA has updated the registry (<http://www.iana.org/assignments/cops-parameters>) for COPS Client Types as a result.

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